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BULLETIN

OF THE

TORREY BOTANICAL CLUB

VOL. 40

FOUNDED BY WILLIAM HENRY LEGGETT, 1870

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NEW YORK
1913
PUBLISHED FOR THE CLUB
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

B3.00

* Deceased, September 14, 1913.

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Dates of Publication

No. 1, for January.	Pages 1– 42.	Issued 20 February, 1913.
No. 2, for February.	43– 96.	18 March, 1913.
No. 3, for March.	97–136.	7 April, 1913.
No. 4, for April.	137–192.	9 May, 1913.
No. 5, for May.	193–248.	20 May, 1913.
No. 6, for June.	249–304.	18 June, 1913.
No. 7, for July.	305–376.	18 July, 1913.
No. 8, for August.	377–460.	13 August, 1913.
No. 9, for September.	461–528.	10 September, 1913.
No. 10, for October.	529–598.	15 October, 1913.
No. 11, for November.	599–652.	24 November, 1913.
No. 12, for December.	653–712.	6 January, 1914.

Errata

Page 45, line 8 from bottom, for *americanus*, read *americanum*.
Page 46, line 1, for *elatus*, read *elatum*.
Page 70, line 11 from bottom, for *Oreoxys*, read *Oreoxis*.
Page 496, line 14, for *paramoena*, read *peramoena*.

Vol. 40 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY 1913

Leaf water and stomatal movement in Gossypium and a method of direct visual observation of stomata in situ

FRANCIS E. LLOYD

In a previous paper* it is shown that the rates of transpiration in cut shoots of the ocotillo, *Fouquieria splendens*, recorded by simultaneous volumetric readings and weighings, are not parallel, but that the loss of water from the plant during the day is in excess of that taken up by the cut end of the shoot from the porometer. This result is in general harmony with the findings of Eberdt† with rooted plants of *Helianthus annuus*. It was not, however, found to be true in my study of the ocotillo that the loss of water takes place at a constant ratio during the hours of daylight, since the whole relation between the income and outgo may be reversed within a short space of time even during daylight by an apparently slight modification of the environmental conditions. This ready susceptibility of the plant lent color to the idea that the differences indicated by volumetric and gravimetric readings are measures of differences in the leaf moisture content, to be more briefly referred to as leaf water in the present paper. Determinations of the amounts of water held within the leaf at various times of the day, these being calculated in percentages of dry weight, showed that such expected differences do occur, but the evidence was incomplete in that the amounts of leaf water were not calculated to a constant, since it must be assumed that

[The BULLETIN for December 1912 (**39**: 567–631. *pl. 40–45*) was issued Jan. 2.]

* The relation of transpiration and stomatal movements to the water-content of the leaves in *Fouquieria splendens*. Plant World **15**: 1–14. Ja 1912.

† See Burgerstein, A. Die Transpiration der Pflanzen 17. Jena, 1904.

the dry weight of the leaf increased during the day. The conclusions drawn rested more especially on the assumption that the leaf water at the close of day is not in material excess of that at the beginning, and upon the fact that during the afternoon there is a sharp rise in the amount of leaf water in spite of a constant, if not a still increasing, dry weight. The hope that during the summer of 1911 the more convincing data based upon constant leaf area could be obtained was not realized, and the evidence therefore still remains incomplete.

In September 1910 a similar attack was made upon the cotton plant at Auburn, Alabama, in which analogous conditions with respect to leaf water were found. During the present year the question has been further studied, the material being obtained from a pure strain of Dixie cotton, the seeds of which were supplied me by the Bureau of Plant Industry.

Plants were grown at Auburn and, under irrigation, at Tucson, Arizona, in the experimental grounds of the Desert Botanical Laboratory of the Carnegie Institution of Washington. My thanks are due to Dr. D. T. MacDougal for his courteous cooperation. The present paper reports upon a portion of the data obtained bearing upon the variation in the amount of leaf water and upon the behavior of the stomata.

METHODS

DRY WEIGHT AND LEAF WATER. The first two series of leaf samples, the figures for which are given in TABLE I, consisted of leaf material placed in tared, cork-stoppered bottles, weighed, oven-dried thoroughly and reweighed. The samples were taken at two hour intervals. The actual work was done by Mr. C. S. Ridgway, to whom my thanks are extended. The samples on which TABLE III is based were taken at assumed critical times, and treated in the same manner by myself.

The data in the remaining tables were obtained by cutting circles of the lamina with a sharp cork borer, placing them forthwith in tared vials and weighing before and after thorough drying. The area of these circles, of which between fifty and sixty were taken for each sample, was calculated, and the exact number of circles taken determined a second time after drying. All data were

calculated to 100 square centimeters of leaf blade. In this way the changes in dry weight and in leaf water for each period were determined.

STOMATA. The measurements given in TABLE IX are average micrometer measurements of a large number of stomata for each period, made on material fixed in absolute alcohol.* Those in TABLE X are measurements of living stomata made in the field by the following method, first hit upon by me during my work at the botanical laboratory of the Carnegie Institution of Washington, at Carmel, California, during the summer of 1911.

A microscope, provided with a condenser and a 4 mm. objective with long working distance, was provided with a cooling cell. This was extemporized by wiring a Soyka flask beneath the substage apparatus. For working in the field, a heavy camera tripod served as a stand capable of ready adjustment in height and position. The illumination consisted of direct sunlight, or when that was not available, a strong artificial light. I used a small miner's acetylene lamp, on the whole fairly satisfactory. A small arc light probably would be better, and indeed necessary when the leaves are very thick.

By means of such strong illumination, properly centered and controlled with the iris diaphragm, it is possible to measure accurately living stomata of leaves with a thickness of 5 mm. without at all injuring them. The method is adapted to the observation of the stomata on a great variety of leaves. including many which are densely covered with trichomes (e. g., *Parthenium argentatum* Gray; *Chenopodium* sp.), which being out of focus do not interfere with the vision under strong illumination. The stomata at the bottom of deep pits, such as are found in the Cactaceae, also can be seen, but so far this has involved the removal of a thick slice of the underlying tissues.

The method presents the further advantage, one of great importance in field work, of permitting the repeated observation of the living stomata, or indeed of a single one, during a sustained period, without injury to the leaf or its removal from the plant. This method has, of course, its limitations in view of the size and

*Lloyd, F. E. The physiology of stomata. Carnegie Inst. Wash Publ. 82. 1908.

shape of the microscope,* but these limitations are not as strait as one might suppose. For the direct visual observation of the living stomata *in situ*, for any reasonable desired period, the method above outlined has a unique value for certain purposes. It will be found, I venture to believe, to be invaluable in supplementing and checking the results obtained by such methods as that of alcoholic fixation (Lloyd, *l. c.*), of the hygroscope (of whatever type), of the porometer,† and of the stomatograph.‡

In using the method one must have a care for his eyes. The adjustment of the illumination must be done with the protection of a color screen, and for this purpose a leaf interposed in front of the objective has served well enough. Under field conditions, especially when one is working for a considerable length of time, dark eyeglasses are very desirable, more particularly if the surroundings are highly illuminated. Small circular discs of dark-tinted glass in various shades to be placed above the ocular have been found advantageous, more especially when the leaf is rather thin, say as thin as the leaf of the cotton.

In the actual observation of the stomata the leaf is placed directly on the stage without any accessories in the form of glass slides or covers. It is held in position by gentle pressure upon it of the index and middle fingers, which, also, embrace the end of the objective. In the eyepiece a micrometer is placed. The absence of a glass slide, which is in any event unnecessary, brings the stomata nearer the focus of the condenser and so improves the definition. As one is dealing with a brilliant area of light, it is quite necessary to have it central, since oblique illumination causes bright reflections from the surface of the stomatal outer vestibule, which may mislead the observer.

LEAF WATER IN PERCENTAGE OF DRY WEIGHT

If we consult TABLE I, which contains the percentages of leaf water calculated to dry weight for two parallel series, treated as nearly alike as possible, it will be seen that when so expressed

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* An instrument of special design, now in course of construction, will obviate many inconveniences.

† Darwin, Francis, and Pertz, D. F. M. On a new method of estimating the aperture of stomata. Proc. Roy. Soc. B. 84: 136–154. 1911.

‡ Balls, W. L. The "Stomatograph." Nature 87: 180. 10 Au 1911.

it varies between the extremes of 318 and 220 per cent. The greatest difference between the two figures for any hour is 26, this greatest discrepancy being found at the 8 and at the 14 hour on September 17. If we assume an error of 13 units and apply a corresponding correction by addition to the smallest and by subtraction from the largest percentage, a difference of 72 units is still afforded. If the correction is similarly applied to the percentages in either series, the difference may be reduced to 46 units, as between the 8 and 14 hour figures. It will appear from these figures that the error of observation is not great, and is probably within five per cent., a conclusion well sustained by the general correspondence of the figures for the two series. It is, further, probably entirely true that the differences are not due to a material error of measurement, but are actual differences in the leaf water of different parcels of material. Since these were not taken by myself, I have compared the differences with those displayed by my data for the ocotillo, upon which I based my conclusions embodied in my paper above referred to,* and I find that discrepancies in similar amounts are to be found in them. The same is true of the data which appear in the present account beyond. They may be due to individual differences, or to differences in groups of plants under various external conditions, or in the positions of the leaves taken. The general correspondence between the two series (FIG. 1) is, however, sufficiently close to warrant drawing the conclusion that during the night there is a rise in the leaf water content (which probably had been preceded by a greater increase previous to the 16 hour) and a decided decrease during the day till 2 P. M. The sharp rise and equally sharp fall indicated between the 18 and 22 hours is puzzling, since if we refer it to change in dry weight, the additional difficulty is introduced of accounting for marked changes in the same. Aside from this peculiarity of behavior the general rise in water content may be referred to the reduction of dry weight, but this involves the assumption that the dry weight was reduced much more rapidly in the period preceding the 18 hour (say between the 14 and 18 hour) than subsequently. A somewhat similarly sharp

* The relation of transpiration and stomatal movements to the water-content of the leaves in *Fouquieria splendens*. Plant World 15: 1–14. Ja 1912.

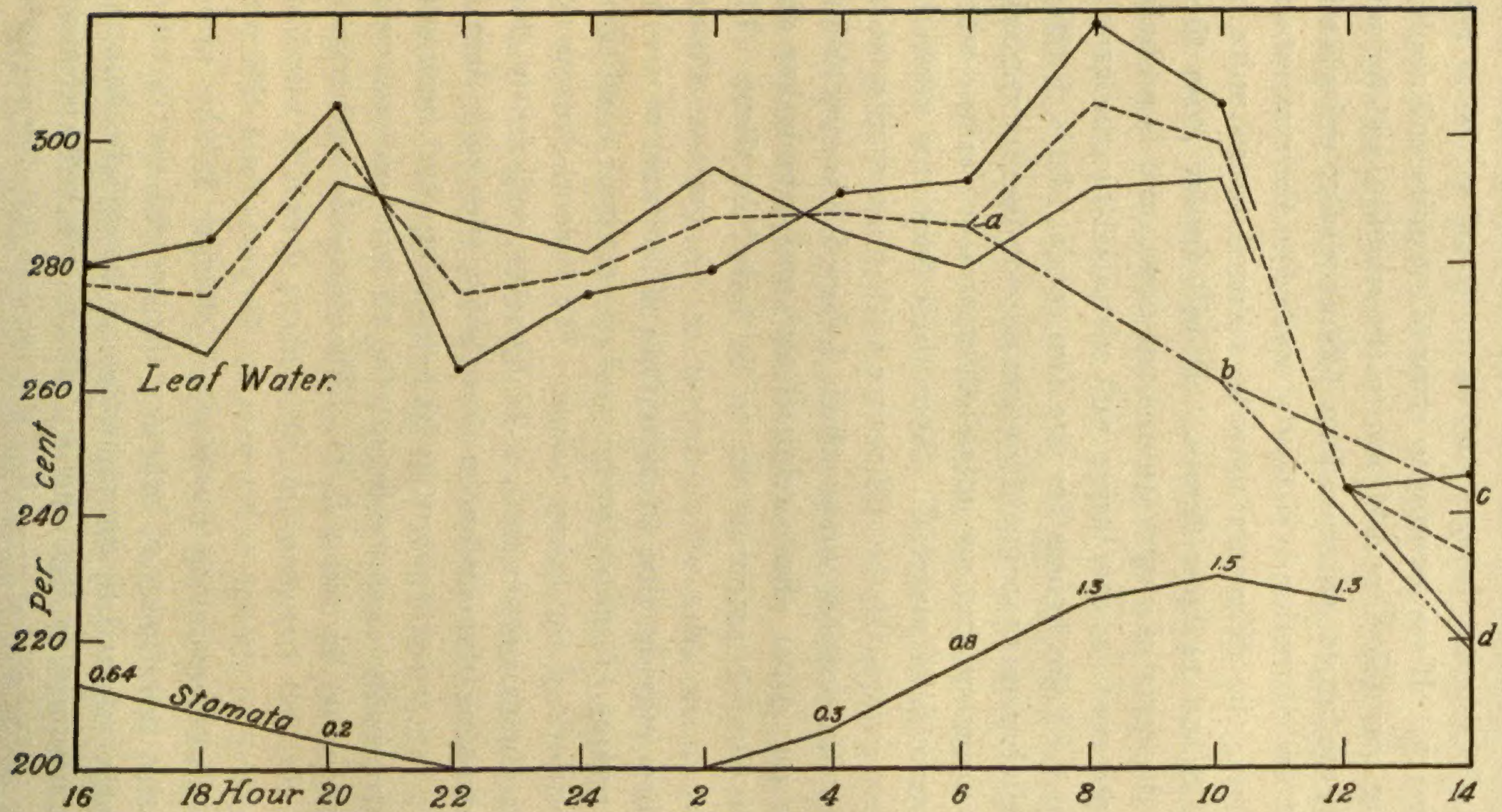

Fig. 1.

Gossypium herbaceum. Graphs for leaf water for two series and for their averages; and for average transverse stomatal dimensions.

rise in water content is indicated after the 6 hour, September 17, continuing till 8. The tables following show such behavior in only one instance (series 12), but it must be understood that the data therein contained were based on material collected on bright days, while those now being considered were taken on a morning (of September 17) during the first few hours of which a general haze prevailed. The single exception, offered by the old leaves collected on October 13, 1911 (series 12, TABLE VIII), differs quantitatively, there being here a difference of 15 units (251 to 266 per cent.) as compared with 19 units (284 to 303 per cent.) in the case before us of September 17.

The value of the comparison is slightly compromised by the fact that the data of TABLE VIII indicate a decrease of dry weight, in an amount that may, however, fall within the limits of error. If no change in dry weight is assumed, the difference in water content in percentage of dry weight would be somewhat reduced.

In view of the further fact that the data for both TABLES V and VIII were obtained after an increase in soil moisture, it seems entirely possible that under certain conditions the first two hours of daylight may be accompanied by an increase in leaf water. This involves as a corollary that the leaf, at the hour of sunrise, may not be completely plethoric of water.

In order to evaluate with some degree of exactness the meaning of the graph embodying the data of TABLE I, I have assumed that on September 17 the dry weight of the leaves increased in the amounts of 9 per cent. on the original weight in the first four hours (6–10) and 17 per cent. in the whole period of eight hours, namely 6–14. These amounts are taken from TABLE VII, series 8, and represent fairly closely the average performance for young leaves. The weighings for the 6 hour are taken as a basis for the calculation, and the leaf water content is assumed to remain constant, the dry weight only increasing. By comparing the ratios thus obtained with those actually observed, as displayed in TABLE II, we see that the calculated value of the ratio at the 10 hour is less than the observed, and at the 14 hour greater (graph *abc*, FIG. 1), the latter indicating a net loss of leaf water. If however, an increase of 30 per cent. on the original dry weight be assumed, an assumption apparently justified in view of the data

in other tables, a net loss of water would not be discoverable (graph *abd*, FIG. 1). It is evident, however, from the directions of the graphs that a negative fluctuation was in progress from the 10 to the 12 hour, followed by increase afterwards. It is also evident that a positive fluctuation begins after the 14 hour, if we suppose the datum for the 16 hour, September 16, to apply approximately to the same hour on September 17.

Although the above evidence is quantitatively somewhat vague, this result is probably due to the application of assumed dry weights based upon data obtained in the following year. Had such data been obtained at the time, their employment would lead to a surer inference. This appears from similar manipulations of the determinations contained in TABLE III of leaf water and dry weight for unknown leaf areas.

In the first three columns are given the known data; in the fifth the average dry weights from TABLE V, which were obtained two days later, these being relative to 100 square centimeters of leaf and assumed to be applicable to August 24. Since the two days (August 24 and 26 at Tucson, Ariz.) were practically identical meteorologically, this assumption is probably entirely justified. By dividing the assumed dry weight into the observed dry weight for each hour the approximate area of the leaf sample taken at that hour is obtained. This affords one term of a ratio (column 4), the other of which is the observed leaf water (column 3) by which the leaf water per 100 square centimeters is derived. This, for each of the three hours of observation, is found in column 7 and is plotted in graph 1, FIG. 2.

Just above this is graph 1*a*, the coordinate points for which were determined as follows. (See TABLE IV.) The same ratios of increase of dry weight were assumed as above. One of the observed dry weight readings in TABLE III was then taken as a standard, and the dry weights for the other two hours were determined by means of these ratios. By assuming the leaf water to be constant the inverse ratios, expressing leaf water as percentage of dry weight, were obtained (column 2, TABLE IV). By comparing these with the ratios (column 4) of the data recorded for each hour (columns 2 and 4) differences are obtained by subtraction which determine the position of the graph of observed leaf water

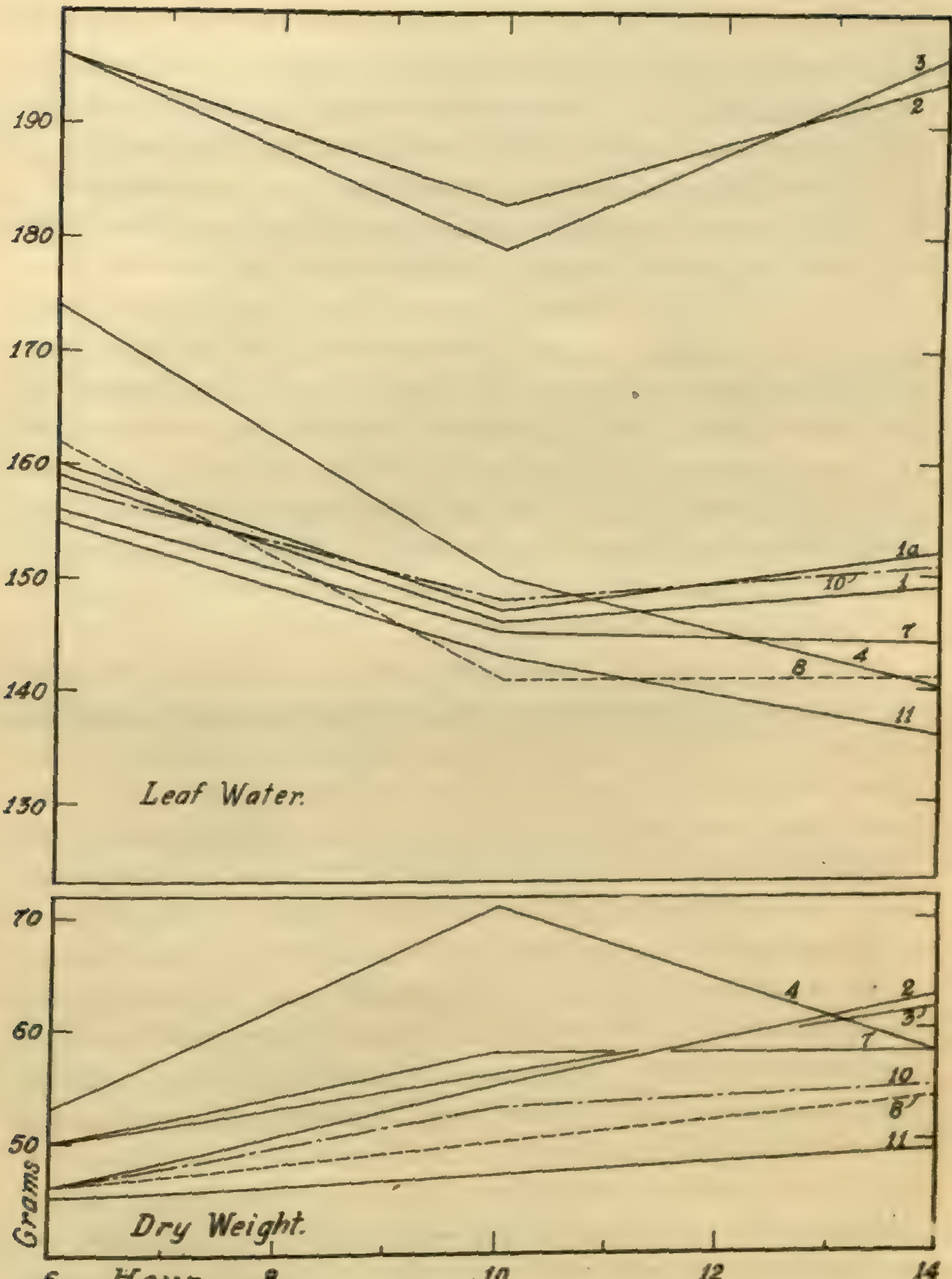

Fig. 2.

Gossypium herbaceum. Graphs for leaf water and dry weights of leaves for the series indicated by numbers corresponding to their numbers in the tables. The ordinates in this and FIG. 3 are the same for the upper and lower portions but have been shortened between 70 and 130 grams. Young leaves.

relative to the graph of constant water when the latter is assumed to be horizontal, as it would be if plotted relative to constant leaf area (column 6). By making the value of the 6.20 hour figure say 160, we obtain results which differ little from those in column 6, TABLE III, in calculating which a variable due to a somewhat inconstant relation between leaf weight and area was admitted.

It is apparent that a much larger increase in dry weight for the first four hours of the day than that assumed, together with far different march of events during the whole period, must have obtained in order to obviate the conclusion that on August 24 there was a net reduction in the amount of leaf water followed by a material recovery.

In addition to graphs 1 and 1*a* are to be found in FIG. 2 the graphs for the young leaves in the remaining tables. The general similarity of the lot further impels the conclusion that graphs 1 and 1*a* are not wide of the truth.

I have taken the above somewhat indirect method of drawing the conclusions desired with reference to the observations recorded in TABLE III, for the purpose of developing a comparison of the observations for the two days, 24 hours apart, at Tucson. We have already examined those of August 24, presented in TABLE III. Those for August 26 are to be found in TABLE V, in which the weights are relative to 100 sq. cm. of leaf blade. Although there was a marked fluctuation in the leaf water on August 26, the loss of water between the 6.20 and 10.20 hours being as great as that on August 24, it is to be noted that the recovery after the 10.20 hour was more rapid on August 26 (graphs 2, 3), and that the absolute amount of leaf water was considerably greater, viz. about 25 per cent., on this day than on August 24. Since the leaves from which the samples were taken were of uniform texture and at similar stages of development, this difference cannot be attributed to variation in these. The difference is due quite probably to the circumstance that on August 25 the ground in which the plants were growing was irrigated. This, if the proper explanation, carries with it the suggestion that it would be well worth while to determine with what precision the soil water conditions may be registered in the condition of the leaves. It is quite possible that the needs of the plant for a water supply

to its roots could be determined by following the changes in leaf water from day to day, and so anticipate a condition of necessity which might curtail growth for a period. Obviously such a procedure would be of practical use only where water is under control.

We now turn to consider the tables which present data relative to a constant leaf area, namely 100 square centimeters.

For the purpose of comparison in what follows, the data embodied in TABLES V–VIII inclusive have been segregated in two sets of graphs, those (in FIG. 2) for young or full-grown but not old and indurated leaves, and those (FIG. 3) for old leaves, rather the worse for wear. They were indurated, torn and more or less discolored, but a consistent effort was made to collect the material from leaves with a healthy appearance. The three series (1 to 3 incl.) for Tucson, Arizona, are included in FIG. 2, since the leaves, while mature, were not at all indurated and, indeed, had perhaps not arrived at full growth, though they were well developed.

Of the seven series of samples from young leaves one only, viz. no. 4, appears to indicate an aberrant behavior, especially as to increase in dry weight, but evidently so as to the loss of water also. If we disregard this case, for which no explanation is offered, the remainder show a general accord. Of the six remaining cases, two (2 and 3), those for Arizona, show an increase considerably in excess of those for Alabama. The ratio of increase for Arizona is 100 to 120 for the first four hours and 100 to 136 for the whole period of eight hours, beginning at 6.20 for the first series; the ratios for the second series are 100 to 112 and 100 to 124. In Alabama the greatest gain for a like period was in the ratio of 100 to 121, while the lowest was from 100 to 109.

Stated in terms of increase of photosynthates, we have for the Arizona plants an accumulation at the rate of 2.25 grams per hour per square meter for the first four hours, and 2.00 grams for the second four hours, for no. 2, TABLE V; the corresponding figures for no. 3 are 1.50 and 1.50. For the young leaves of Alabama plants, excluding series 7, TABLE VI, the range of increase (when there was any increase at all) is from 0.5 to 1.6 grams. Sachs' determinations for the sunflower were 1.88 and 1.7, and for the cucumber 1.5 gr. Brown and Escombe's datum for the sunflower is, however, 0.714 gr. Although my own data were

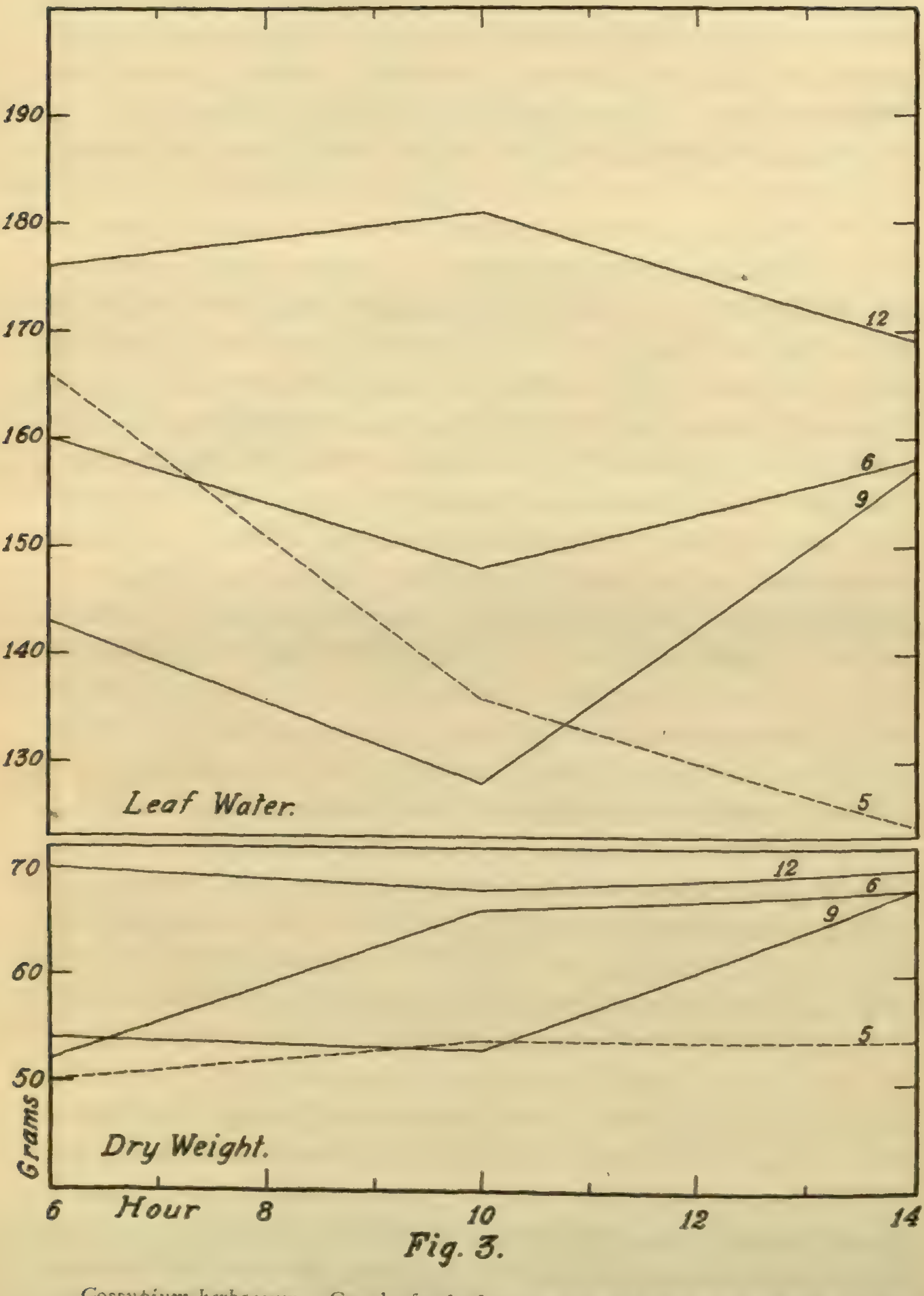

Fig. 3.

Gossypium herbaceum. Graphs for leaf water and dry weights of leaves for the series indicated by numbers corresponding to their numbers in the tables. Old leaves.

not obtained with a view primarily to obtaining light on the accumulation of carbohydrates, the general correspondence of the Alabama figures with those quoted may be noted. The greater efficiency of the Arizona plants possibly may be due to the fuller development of the leaves. This would be indicated by the performance of the old leaves on October 1 and 8 (series 6 and 9), which showed an increase of 30 and 26 per cent., but more surely, if it were not for the general irregularity of their behavior and the entire failure to get an increase at all in series 12 and only a very slight one in series 5. On the other hand the light conditions in Arizona are much more favorable in view of the frequent cloudiness in Alabama. The days on which the Alabama material was collected were partially cloudy, while that from Arizona was taken on continuously clear days.

The old leaves betray a much more erratic behavior and the data lead us to no safe conclusion. In the two cases, TABLE VI, series 5; TABLE VII, series 9, however, in which there was a marked increase in dry weight, there was also a marked recovery of leaf water after the 10 hour. By contrast, however, the leaves that contained the greatest quantity of water, series 12 of October 13, were the least efficient photosynthetically, a circumstance which throws doubt on the inference that the failure of the leaves of series 5, taken from all parts of the plants, to add to their dry weight after the 10 hour, was due to a marked loss of water during the corresponding period.

STOMATAL MOVEMENT

A glance at FIG. 2 will show that after the 10 hour has been reached there is a distinct tendency to recover the leaf water lost during the earlier hours. It is important to inquire whether this tendency, which begins to make itself evident during the part of the day when transpiration rates may be assumed to be the highest, is in correlation with the behavior of the stomata.

Balls,* in Egypt, found by means of his newly devised stomatograph that the stomata of the cotton slowly close as the hottest part of the day approaches, completing the closure as the sun passes behind neighboring trees at 13.40 hr., remaining closed all

* Balls, W. L. The "Stomatograph." Nature 87: 180. 10 Au 1911.

the succeeding night. They open slowly after sunrise, but more rapidly after the sun strikes the leaf at about 7, attaining the maximum opening at 9, but thereafter closing steadily in spite of brilliant illumination. So far as I am aware this is the only record of the behavior of the stomata in cotton.

The measurements given in TABLE X, made microscopically and at the same time by two observers, Mr. C. S. Ridgway and myself, in the manner earlier described, correspond in a rather striking way with Balls' conclusions, just indicated. Each formula represents the minimum and maximum width of the stomatal pores on the upper and under sides of the same leaf. When a very few stomata displayed extreme dimensions, these are enclosed in parentheses. It may be regarded that these would on account of their small numbers affect but little the general diffusive capacity of the stomata taken as a whole.

It is evident that during the night and until 6.20 there was no measurable opening movement. This must not be taken to mean that all the stomata were entirely closed. TABLE IX gives stomatal dimensions from preparations made by the alcohol method, in which it is evident that some opening in a few stomata may be observed at any time during the night. The initial opening on September 30, 1911, occurred about 6.30, from which hour on a progressive opening movement was followed, the stomata of the lower faces opening somewhat in advance of those of the upper, though some exceptions to this appear, as at 7.50 and 8; while Livingston and Estabrook* found, in several kinds of stomata, that the upper close and open more rapidly or close more completely than the lower. The maximum average pore width was attained during the period between 7.45 and 9, though the widest openings were seen at 8.20. Because of the extreme sizes of opening then noted, leaves of similar size and exposure were examined to verify the observation, but they were no more seen during the morning, except in one instance an hour later. The closing phase was at once entered upon, but it is evident from the figures that this movement was less uniform in all the leaves taken together than the opening. This may be readily understood

* Livingston, B. E., and Estabrook, A. H. Observations on the degree of stomatal movement in certain plants. Bull. Torr. Club **39**: 15–22. 12 F 1912.

when it is appreciated that the stomata of cotton are quite sensitive. I observed, both in Alabama and in Arizona, that at the same hour a leaf in the shade and one in the sun were physiologically antipodal in this regard. Thus, at 8.30, August 24, at Tucson, Ariz., the stomata of a leaf in the shade were closed both above and below, while those fully exposed to sunlight on another leaf were 0–10μ wide above, and 2–4 μ below. Similar conditions are displayed by the leaves observed at the 10 hour, TABLE X. At the same hour it was noted that the stomata near the apex of a leaf were closed while those near the base were open, a condition readily understandable if wilting is progressive from the apex of the leaf downward.

As between young and old leaves, the latter being still physiologically active, it is not clear that there was a more pronounced tendency in one kind than in the other either toward opening or closing, nor that the leaves near the base of the plant were more favorably placed than those three feet above, at or near the top. Indeed, that the upper leaves close their stomata less early than those near the base seems indicated, and this is in harmony with Pringsheim's findings,* who believes that the apical parts of the plant withdraw water from the older, the result of more rapid transpiration from the younger organs.

The data of the table which we have been considering must be regarded, however, rather as an indication of the usefulness of the method of microscopical observation in the field after the manner already described. The measurements were taken rather at random, and as the plants were nearing the end of their career, the larger leaves being somewhat *passées*, while the young were from "second growth" shoots, at the tops of the plants. Their general indications, however, I believe, may be relied upon, namely that the maximum opening of the stomata is reached at about 8.30 in the morning. It has been the invariable experience of three observers during the season of 1911 at Auburn, and of one of them at Tucson, that wilting of the leaves becomes first evident at about this hour or somewhat later each day, when sunlight conditions prevail. The reduction of leaf water leading to

* Pringsheim, E. Wasserbewegung und Turgorregulation in welkenden Pflanzen. Jahrb. Wiss. Bot. 43: 89–144. 1906.

this condition* has been demonstrated quantitatively above, the minimum amount being found, in these determinations, at the 10 hour or somewhat later. It becomes evident that the opening of the stomata is accompanied by a net loss of water by the leaf, more being given off by transpiration than can be obtained to replace it, as I have shown to occur by comparative volumetric and gravimetric determinations in *Fouquieria splendens*.† The results of similar experiments with cotton may be said, in anticipation of their publication, to harmonize fully with those on *Fouquieria*.

Concerning the relative behavior of young and old leaves it may be further pointed out, that so far as the evidence goes in the present paper there is little against either of the alternate views that this loss of leaf water is better resisted by the young or by the old. The numbers of stomata per unit area in the young leaves are considerably greater. An important inquiry at this point is in regard to the relative extent of the internal evaporating surfaces,‡ but though we do not find the answer, we may be sure that it is sufficient in young leaves to lead to wilting, and that the stomata do not head off the net loss during the period of advancing temperature, insolation, and evaporating power of the air.

It is quite possible that determinations of the amount of leaf water at smaller intervals of time would lead to the finding that the loss is more sudden, after it once begins, in old leaves than in young ones, and that this may be connected with the relative diffusive capacity of the stomata in consecutive intervals of time. I have arrived at this suggestion by a comparison of the dimensions of the slightly open pores of young and old stomata, and by calculating their relative diffusive capacities.§ It develops that in old stomata the edges of the pore are more stiffly reinforced, and that in opening they separate from each other throughout

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* Livingston, B. E. Relation of the daily march of transpiration to variations in the water content of foliage leaves. Bot. Gaz. **53**: 309–330. 1912.

† Lloyd, F. E. The relation of transpiration and stomatal movements to the water content of the leaves in *Fouquieria splendens*. Plant World **15**: 1–14. Ja 1912.

‡ Bergen, J. Y. Relative transpiration of old and new leaves of the *Myrtus* type. Bot. Gaz. **38**: 446–451. D 1904.

§ Livingston, B. E., and Estabrook, A. H. Observations on the degree of stomatal movement in certain plants. Bull. Torr. Club **39**: 15–22. 12 F 1912.

nearly their whole length at once, making a long narrow opening. Thus I find that the pore lengthens from 12 to 13.5 μ in one case, and from 9 to 10.5 μ in another, while the width reaches 1.8 and 2 μ respectively, these transverse measurements being applicable throughout the major portion of the length of the pore. Such stomata probably attain a relatively high diffusive capacity more quickly than young ones, in which pores, because of the flexibility of their edges, they attain their full length gradually. In the only series of preparations I have at hand the shortest pore I find is 4.5 μ long and 1 μ wide. Its index of relative diffusive capacity is 2.12. Assuming that in further opening its dimensions advance to 8.4 by 1 μ (those of a similar stoma in the same preparation) and then to 9 by 1.5 μ, the indices would be, for these dimensions, 2.9 and 3.67, whereas an older stoma would have measurements such as 14 by 0.8 μ, or 12 by 1.5 μ, with the indices 3.35 and 4.24, respectively. That is, for the same width of pore, the maximum length is reached much more rapidly and a relatively high diffusive capacity more quickly in older than in younger stomata. If relations such as these obtain, as the evidence before us appears to indicate, we may well think that they may affect the rate of incipient drying,* either with or without appreciable wilting. Differences of this kind may help to account for the results obtained by Bergen,† who found that the old leaves of sclerophyls transpire more than young leaves which have just attained their maximum area, though he further observed that the same relation holds for cuticular transpiration as well. In this regard, Pringsheim's work, already referred to, may not be overlooked. It is to my mind doubtful, in view of the results on loss of leaf water presented in this paper, that the differences observed by Bergen‡ as between sun and shade leaves depend upon the water carrying capacity of the vascular tissues.

Turning to the data of TABLES I and IX, as represented in FIG. 1, it becomes apparent that the sharp rise in leaf water between the 6 and 8 hours neither harmonizes with the results given in the remaining tables, nor does the curve of stomatal openings

* Livingston, B. E. *l. c.*

† Bergen, J. Y. Relative transpiration of old and new leaves of the *Myrtus* type. Bot. Gaz. 38: 446–451. D 1904.

‡ Bergen, J. Y. Transpiration of sun leaves and shade leaves of *Olea europaea* and other broad leaved evergreens. Bot. Gaz. 38: 285–296. O 1904.

for the hours of observation bring out the relations between these and loss of leaf water in sufficient detail. That there should have been increase in leaf water in the amount of about 7 per cent. during the period (6 to 8) when the stomata were opening from 0.7 to 1.4 μ, must have been due to meteorological conditions, though it is still not clear why the maximum leaf water had not been attained by the 6 hour, unless it should be shown that such a condition does not always intervene even in the early morning hours before sunrise.

The flatness of the curve of stomatal opening after the 8 hour, it is likely, does not properly represent the facts, since from the evidence in TABLE X there was probably a considerable opening and closing between 8 and 10, with the maximum diffusive capacity reached at about 9. If, aside from this, the curve of stomatal opening is true, it would seem to indicate that the loss of leaf water from 300 to 240 per cent. took place without a sufficient amount of wilting to involve closure of the stomata, and that the leaf therefore had not passed beyond the condition of drying incipient to wilting. As no observations were recorded to test the truth of this conclusion and no measurements of the meteorological conditions beyond the note that there was a general haziness until the 10 hour were made, we perhaps may be permitted to draw the lesson, that in such studies it is of utmost importance that the integral effect of such conditions should be known before any adequate interpretation of the water relations of the plant may be had. At present the most efficient method to this end is that of measuring evaporation with the blackened porous cup.* In a future paper it is proposed to display the results which have been obtained in field studies of cotton in the light of such integration.

Reference has been made above to the daily wilting of the leaves, observable at first at about the 9 hour. The stomatal measurements would seem to indicate that after this hour there is a rather steady closure. It therefore would be of importance to determine at what hour the maximum transpiration rate occurs when these conditions prevail. In anticipation of such determina-

* Livingston, B. E. A radioatmometer for comparing light intensities. Plant World 14: 96–99. Ap 1911; Light intensity and transpiration. Bot. Gaz. 51: 417–438. D 1911.

tions, now possible by the use of the method I have described above, and with reference also to F. Darwin's* verification in cooperation with Pertz, by means of the porometer, of his earlier work on the temporary opening of stomata during wilting, I measured by weighing the rates of transpiration of a piece of a cotton plant during wilting. After the cutting off, the cut was greased and the piece was suspended on a balance, the loss of weight being determined at intervals of several minutes, beginning at 7.22 when the stomata were open but had not reached their maximum. The leaves were turgid. The figures obtained (TABLE XI) show that between 8.02 and 8.07, following a steady fall in the rate, there was a temporary rise, and while this was very small when compared with Darwin's data, it may be a phenomenon comparable with that observed by him. However, that the stomata open after wilting sets in still appears doubtful to me. I have watched microscopically the stomata of the cotton, in addition to those of several other species, during the wilting period, beginning with the partly as well as fully opened condition, and I have never observed any such movement. There is at first no change. As wilting sets in, closure commences and proceeds steadily till complete, and I have observed no subsequent opening. Obviously further investigation is required to throw light on these differences.

CONCLUSIONS

In the foregoing paper a method for the direct observation and measurement of stomata *in situ* is described. The method is adapted to field work by night and by day.

Leaf water, stated in percentage of dry weight, was found to vary in the cotton plant under usual conditions between 318 and 220 per cent. On the day of observation the minimum leaf water content was reached at the 14 hour or thereabouts. This reduction represents a net loss as shown by the determinations made relative to unit area and, therefore, with quantitative regard to dry weight.

The amount of loss of leaf water when thus determined is from 7 to 15 per cent. on the initial amount at sunrise, under the condi-

* Darwin, F., and Pertz, D. F. M. On a new method of estimating the aperture of stomata. Proc. Roy. Soc. B. 84: 136–154. 1911.

tions prevailing when the observations were made. Among these conditions it may be mentioned incidentally that the soil was well drained and rich in moisture at the time. Severer circumstances would no doubt effect a still greater loss. The observed loss, however, may be taken as indicative of a usual phenomenon, the reality of which is made evident in an observed daily wilting of the leaves beginning at about the 9 hour, detectable not alone by change in position (since this may occur as a phototropic response) but by flaccidity. The case may be otherwise stated by saying that under usual day conditions, with sunshine, the roots are unable to supply loss of water from the leaves. Balls'* view that the water supply is the limiting factor of growth, and his observation that no growth takes place under the Egyptian sun appear to be quite applicable to Alabama. With regard to the amount of growth in Alabama, preliminary measurements, prompted by the results obtained from the determinations of leaf water, indicate that even under the presumably more favorable humidity conditions obtaining here growth does not take place for the major portion of the day, since during the latter part of the growing season an actual daily shrinkage in stem and leaf length has been observed. I can hardly concur, however, with Balls in his view that because growth does not take place in sunshine this is to be interpreted as unfavorable. Comparative measurements on the same variety of cotton obtained in Arizona betray a no more unfavorable reduction of leaf water than in Alabama, when there is sufficient water in the soil. There is evidence that variations in soil moisture are registered in both the absolute leaf water content and in the rate of recovery after the minimum quantum for the day has been reached, while the loss during the first part of the day appears to be less affected. It would seem that the real test is the growth integer for the season, and it is not evident that, with irrigation, the conditions in the semiarid Arizona desert at all events are unfavorable from this point of view. A hot sunshiny day after all may be good for cotton, but this good may not be apparent in growth at the time. This is indicated by the amount of photosynthates formed (measured with small error due to well

* Balls, W. Lawrence. The physiology of the cotton plant. Cairo Sci. Jour. 4: 1–9. Jl 1910; Cotton investigations in 1909 and 1910. Cairo Sci. Jour. 5: 221–234. S 1911.

understood causes) by the increase in dry weight. Two series in Arizona gave increases of 24 and 32 per cent. for 8 hours. In Alabama, with the exception of one series of old leaves in which there was no apparent change in weight, the increases ranged from 6 to 25 per cent., the latter being one instance out of a total of seven series. Whatever may be said of increase in dimensions, therefore, it remains the fact, that in spite of the hot unmodified Arizona sun shining throughout continuously cloudless days in August, more energy in the form of carbohydrates was made available than in the similar periods in Alabama. It is proper, however, to recall that the leaves studied in Arizona were of fuller development, while those in Alabama were either rather young (10–15 cm. transverse measurement) or overmature.

It is obvious that it will be of great interest to make careful measurements of growth, as indeed of other functions, for comparison with those of Balls in Egypt.

The stomata are practically closed at night, but nevertheless show a tendency to open during the early morning hours.* The more obvious daily opening begins at about 6.30, in Alabama in September, and the maximum is reached at about 8.30 or 9, after which closure progresses until 11 or somewhat later. A concomitant and appreciable wilting takes place, correlated with the reduction of leaf water. During wilting there appears to be no "temporary opening" of the stomata, although I have observed a measurable but not very marked rise in the rate of transpiration about a half hour after wilting starts in, followed by a sudden reduction of rate.

*Lloyd, F. E. The physiology of stomata. Carnegie Inst. Wash. Publ. 82. 1908; Darwin, Francis, and Pertz, D. F. M. On a new method of estimating the aperture of stomata. Proc. Roy. Soc. B. 84: 136–154. 1911.

TABLE I

Gossypium herbaceum. Auburn, Ala., Sept. 16–17, 1910. Leaf water in percentage of dry weight.

Hour	Series I	Series II	Average
16	274	280	277
18	266	284	275
20	293	306	299
22	287	263	275
24	282	275	278
2	295	279	287
4	285	291	288
6	279	293	286
8	292	318	303
10	293	305	299
12	244	244	244
14	220	246	233

TABLE II

Observed leaf water expressed in percentage of dry weight and the percentages obtained by assuming a 9 per cent. increase in dry weight for the first four hours and 17 per cent. and 30 per cent. for the second four hours.

Observed				Calculated		
Hour	Dry wt.	Water	Per cent. water	Dry wt	Water	Per cent.
6	4.15	11.79	284			
10	3.70	11.07	299	4.52*	11.79	261
14	5.53	12.87	233	4.86†	11.79	243
	5.53	12.87	233	5.40‡	11.79	218

TABLE III

Gossypium herbaceum. Series 1, Tucson, Ariz., Aug. 24, 1911. Amount of leaf water in percentage of dry weight and the same calculated to 100 sq. cm., the average dry weights in TABLE V, being assumed as applicable to the material on which this table is based.

Hour	Observed weights		Area	Weight per 100 sq. cm.	
	Dry	Water		Dry (assumed)	Water
6.20	10.55	34.36	2153	0.49	1.59
10.00	10.84	28.02	1918	0.565	1.465
13.30	12.12	28.78	1933	0.627	1.493

* 4.15 plus 9 per cent.

† 4.15 plus 17 per cent.

‡ 4.15 plus 30 per cent.

TABLE IV

Leaf water relative to constant area computed from the observed weights in TABLE III. The average rate of increase in dry weight recorded in TABLE V is assumed.

Hour	Ratios of water (= C) to dry weight		Observed ratios water to dry weight		Water to dry weight, area = C	Leaf water per 100 sq. cm.
6.20	326	100	326	100	100	1.60
10.00	285	87.5	259	79.5	92	1.47
13.30	254	77.7	238	73.0	95	1.52

TABLE V

Gossypium herbaceum. Tucson, Ariz., Aug. 26, 1911. Weight of water and dry weight in grams per 100 sq. cm. of leaf at the hours indicated. Two series Irrigated Aug. 25.

Series	6.20		10.20		14.15	
	Dry wt.	Water	Dry wt.	Water	Dry wt.	Water
2	0.46	1.96	0.55	1.83	0.63	1.94
3	0.50	1.96	0.56	1.79	0.62	1.96
Ave. . . .	0.48	1.96	0.55	1.81	0.62	1.95

TABLE VI

Gossypium herbaceum. Auburn, Ala., Oct. 1, 1911. Weight of water and dry weight per 100 square centimeters of leaf at the hours indicated. Series 4, young newly developed leaves near the top of the plant; series 5, mixed, old leaves from various parts of the plant; series 6, old leaves near the top of the plant.

No.	6		10		14.30		18	
	Dry wt.	Water	Dry wt.	Water	Dry wt.	Water	Dry wt.	Water
4	0.534	1.74	0.71	1.50	0.58	1.40	0.64	1.50
5	0.50	1.66	0.54	1.36	0.54	1.24	0.56	1.38
6	0.524	1.60	0.66	1.48	0.68	1.58	0.64	1.69
	0.515	1.66	0.64	1.45	0.60	1.41	0.60	1.52

TABLE VII

Gossypium herbaceum. Auburn, Ala., Oct. 8, 1911. Weight of water and dry weight per 100 sq. cm. of leaf at the hours indicated. Series 7, material from *alternate sides* of the same leaves on ten plants; series 8, young leaves taken indiscriminately from plants in "lot 2, closely planted in rows." All leaves in both series from fresh secondary growth at the tops of plants; series 9, old leaves taken indiscriminately: marked "old."

No.	6		11.00		14.30	
	Dry wt.	Water	Dry wt.	Water	Dry wt.	Water
7	0.50	1.56	0.58	1.45	0.58	1.44
8	0.46	1.62	0.50	1.41	0.54	1.41
9	0.54	1.4	0.53	1.28	0.68	1.57
Ave. . . .	0.50	1.54	0.54	1.38	0.60	1.47

TABLE VIII

Gossypium herbaceum. Auburn, Ala., Oct. 13, 1911. Dry weight and weight of water per 100 sq. cm. of leaf at the close of 0.83 inch precipitation during the preceding 48 hours.

Series 10, material taken by a leaf punch from alternate sides of the same leaves on ten plants, not more than three circles being taken at one time from a given leaf. Young leaves (second growth) taken near the top of plant; series 11, young leaves of the same kind selected indiscriminately from "lot 2, 1911"; series 12, material taken as in (1) above from old leaves near the top of the plants.

Series	6.30		11.00		15.00	
	Dry wt.	Water	Dry wt.	Water	Dry wt.	Water
10	0.46	1.58	0.53	1.48	0.56	1.51
11	0.45	1.55	0.47	1.43	0.49	1.36
12	0.70	1.76	0.68	1.81	0.70	1.69
Ave. . . .	0.55	1.63	0.56	1.57	0.58	1.52

TABLE IX

Gossypium herbaceum. Auburn, Ala., Sept. 16–17, 1910. Average transverse dimensions of stomata of the upper and lower sides of the leaf. Extreme measurements are given in parentheses.

Hour	Average transverse diameter, micra	Hour	Average transverse diameter, micra
16	0.7 (4) 0.6 (3)	4	0 (2) 0.5 (4)
20	0.2 (2) 0.2 (3)	6	0.5 (1) 1.0 (1)
22	0 (3) 0 (3)	8	1.5 (5) 1.2 (4)
24	0 (1) 0 (1)	10	1.5 (5) 1.5 (4)
2	0 (3) 0 (2)	12	1.5 (6) 1.2 (4)

TABLE X

Gossypium herbaceum. Auburn, Ala., Sept. 30, 1911. Stomatal measurements in field plants. Averages in bold face type.

6 $\frac{0}{0}, \frac{0}{0}$

6.20 $\frac{0}{0}, \frac{0}{0}$

6.30 $\frac{0-2}{0-3}, \frac{0}{0}$ (0.9)

6.40 $\frac{0}{0-2}, \frac{0}{0-2(4)}, \frac{0}{0-2(4)}$ (0.6)

6.55 $\frac{0-4}{0-4}, \frac{0-3(4)}{0-4}$ (2)

7.00	$\frac{0-4(6)}{0-3(5)}$ (2)		
7.20	$\frac{0}{0-(4)}$, $\frac{0-3(4)}{0-4(6)}$, $\frac{0-(3)}{0-(4)}$ (2)		
7.25	$\frac{0-6}{0-6}$, $\frac{0-4}{0-6}$, $\frac{0-6}{0-6(7)}$ (4.5)		
7.35	$\frac{0-3(6)}{0-5(8)}$, $\frac{0-4}{0-6}$ (2.5)		
7.40	$\frac{0-(4)}{0-4}$, $\frac{0-3(6)}{(0)-5(9)}$, $\frac{0-4}{0-4}$, $\frac{0-4(6)}{0-6(8)}$ (2.5)		
7.45	$\frac{0-6(8)}{0-8}$, $\frac{0-4(6)}{0-4(8)}$, $\frac{0-8(12)}{4-12}$ (4.5)		
7.50	$\frac{0-6(8)}{0-4(6)}$, $\frac{0-8(10)}{0-8}$, $\frac{(0)-5(7)}{0-4(6)}$ (3)		
8.00	$\frac{0-5(10)}{0-3(6)}$ (2)		
8.20	$\frac{(0)4-8}{(0)4-8(10)}$, $\frac{0-4(8)}{0-8(12)}$, $\frac{(0)2-8}{0-8(12)}$, $\frac{0-6(8)}{0-6(10)}$ (4.5)		
8.50	$\frac{3-8}{0-8(10)}$, $\frac{0-6(8)}{0-6(10)}$ (4)		
8.55	$\frac{0-8}{0-10}$, $\frac{(0)-6(10)}{(0)-6(10)}$ (4.5)		
9.20	$\frac{0-4(8)}{0}$, $\frac{0-3(8)}{0}$ (2.5)	Notes.	
9.25	$\frac{0-4(8)}{0-6(8)}$, $\frac{0-3(4)}{0-1(4)}$ (2)		
	$\frac{0-6}{0-(4)}$, $\frac{0-4}{0-1(4)}$ (2)		
9.55	$\frac{0-8}{0-10}$, $\frac{0-1(4)}{0-1}$ (2.5)		
	$\frac{0-2}{0-1}$, $\frac{0-4(6)}{0-3(6)}$ (1.5)		
10.00	$\frac{0(1)}{0(1)}$, $\frac{0(1)}{0(1)}$ (0)	Shade	Similar leaves.
	$\frac{0-4}{0-3(6)}$, $\frac{0-2(4)}{0-3(4)}$ (1.5)	Sunlight	
	$\frac{0}{0}$, $\frac{0}{0}$ (0)	Large leaf; sunlight.	
	$\frac{0-10(12)}{0-6}$, $\frac{0(3)}{0-2(4)}$ (2)	Two young leaves of same age, twig, and exposure; apex of plant.	
10.35	$\frac{0-8(10)}{0-(8)}$, $\frac{0-1(2)}{(0)2-4(8)}$ (3)	Two mature leaves on same twig.	
	$\frac{0-1}{0}$, $\frac{0}{0}$ (0)	Two old leaves, apparently wilted.	
10.40	$\frac{0}{0}$, $\frac{0}{0}$ (0)	Two small young leaves near base of plant.	
	$\frac{0-1}{0(3)}$, $\frac{0-2(4)}{(0)3}$ (1.5)	Two small leaves near base of plant.	
	$\frac{(0)2-4}{0(4)}$, $\frac{0-1}{0}$ (0.8)		

	$\frac{0(3)}{0}, \frac{0-2(4)}{0(2)}$ (0.4)	Two very young leaves at top of plant, same light exposure.
11.00	$\frac{0(2)}{0(2)}, \frac{0(2)}{0(2-6)}$ (0)	Two mature leaves tops of neighboring plants, with same exposures.

TABLE XI

Gossypium herbaceum. Sept. 27, 1911. Transpiration during wilting. Top of chief shoot, with 3 mature leaves and 5 young leaves. Cut end vaselined. Weighed indoors in bright diffused light.

Hour	Weight, grams	Loss	Rate per minute
7.22	19.3		
27	19.06	0.24	.048
32	18.89	0.17	.034
38	18.70	0.19	.032
44	18.56	0.14	.024
50	18.46	0.10	.017
56	18.36	0.10	.017
8.02	18.26	0.10	.017
07	18.16	0.10	.020
16	18.07	0.09	.001
31	17.89	0.18	.0012
40	17.76	0.13	.0014
50	17.65	0.11	.0011
9.02	17.51	0.14	.0012
11	17.41	0.10	.0011
27	17.23	0.18	.0012

NOTE. This paper is a partial report of work done as an Adams Fund project at the Alabama agricultural experiment station.

McGILL UNIVERSITY.

On a possible relationship between the structural peculiarities of normal and teratological fruits of Passiflora gracilis and some physico-chemical properties of their expressed juices

Ross Aiken Gortner and J. Arthur Harris

We present here an account of first studies on the physical properties of the juice expressed from normal and teratological plant organs.

Materials

The plants furnishing the fruits used were vigorous and normal in growth but were transplanted from the greenhouse to the field too late to attain the largest size or to produce the maximum number of mature fruits before the oncoming of cold weather. We were, therefore, somewhat limited in amount of material, but altogether 10,929 fruits were dissected in obtaining abnormals and normals for checks. Not many more could have been worked over with the facilities available.

The fruits for which adequate samples could be secured fell into the following classes:*

(*a*) Normal fruits. Six external sutures, three placentae, no prolification. A sample of such fruits, collected as described below, served as a check for each of the samples of abnormals.

(*b*) Seven external sutures, three placentae, no prolification; 2 samples, 1, 2.

(*c*) Eight external sutures, three placentae, no prolification; 1 sample, 3.

(*d*) Eight external sutures, four placentae, no prolification; 9 samples, 4–12.

(*e*) Six external sutures, three placentae, slight and generally abortive prolification of three external carpels; 1 sample, 13.

* For a general account of prolification in *Passiflora* see a paper by J. A. Harris, Prolification of the Fruit in *Capsicum* and *Passiflora*. Ann. Rep. Missouri Bot. Gard. 17: 133–145. 1906.

(*f*) Six external sutures, three placentae, slight and generally abortive prolification of four external carpels; 4 samples, 14–17.

(*g*) Eight external sutures, four placentae, slight and generally abortive prolification of three external carpels; 1 sample, 18.

(*h*) Eight external sutures, four placentae, slight and generally abortive prolification of four external carpels; 2 samples, 19, 20.

(*i*) Six external sutures, three placentae, large living prolification of four external carpels; 2 samples, 21, 22.

(*j*) Eight external sutures, four placentae, large living prolification of four external carpels; 1 sample, 23.

METHODS

The rarity of the abnormal fruits is a source of great difficulty in the collection of the samples. As the fruits were dissected, each abnormal was placed in a dish provided with a ground glass cover and containing bibulous paper saturated with water in order to prevent, as far as possible, any drying out of the fruits. A normal to serve as a check was at once opened and placed in a similar receptacle. These two were kept side by side until it was necessary or convenient to combine abnormalities belonging to the same type and their check fruits in a pair of larger moist chambers. As soon as a sample of any type conveniently large for the extraction of juice was secured, the collection of another general sample and check was begun.

Thus, while the different samples of abnormals came from various plants and were necessarily held for varying lengths of time, *the fruits of each sample and of the check with which it was compared were drawn in equal numbers, and at the same time, from the same individual plants and received parallel treatment in every detail.*

The juice was secured by means of a large "beef-juice" press. It was filtered clear through a dry barium filter (S. & S. No. 589), and the depression of the freezing point (Δ) determined in the well-known Beckmann apparatus. The specific gravity of the sap at 20° C. was found by weighing in a pycnometer holding 5.2405 grams of water at 20° C. The concentration of dissolved substances was determined by evaporating a measured volume (10–15 c.c.) to dryness in glass weighing bottles, first in a water oven

at the temperature of boiling water and then completing the desiccation by heating to 105° C. for several hours.*

Depression of the freezing point, Δ, specific gravity, $d(20°/20°)$, and total solids in 100 c.c. of juice, s, are the only direct determinations entered in the table. From these, osmotic pressure in atmospheres, P, and the average molecular weight of the substances dissolved in the plant sap, M, have been calculated by the formulae

$$P = 12.060\Delta - 0.021\Delta^2$$

$$M = 1890\left(\frac{\frac{s}{d}}{100 - \frac{s}{d}}\right)\Big/\Delta$$

* It may not be amiss to consider the accuracy of our numerical data. Inasmuch as we were not concerned with the *absolute* depression of the freezing point, but only with the sign and amount of variation between normal and abnormal juices, we have not taken all of the precautions which would be necessary were the *absolute* values desired. We have found that the degree of pressing the fruits has no influence on the *relative* values, providing that the normal is treated in the same manner as the abnormal. For example: a sample was pressed lightly and the freezing point of the expressed juice determined; then the residue was pressed so that a considerable amount of juice was again obtained, and this juice was added to that from the first pressing. The *absolute* values are much different but the *relative* value remains approximately the same.

	Abnormal	Normal	Difference
Light pressing.....	$\Delta = 0.677°$ C.	$\Delta = 0.603°$ C.	+ 0.074° C.
Heavy pressing....	$\Delta = 0.705°$ C.	$\Delta = 0.628°$ C.	+ 0.077° C.

A constant *relative* value is also obtained when large samples are divided into two portions and the juice expressed from the second portion after an interval of four days, showing that holding the fruits for several days does not affect the *relative* values. The *absolute* and *relative* values of a pair of samples treated in this manner follow:

	Abnormal	Normal	Difference
First value.....	$\Delta = 0.587°$ C.	$\Delta = 0.618°$ C.	− 0.031° C.
Four days later....	$\Delta = 0.677°$ C.	$\Delta = 0.713°$ C.	− 0.036° C.

We have not corrected the depression of the freezing point for the amount of supercooling before freezing, for the same reason. That is, we are concerned only with a *relative* value. We have had occasion in several instances to repeat a determination, sometimes as much as twenty-four hours later, on the same sample of juice, and in only one instance did the repetition vary from the original determination by as much as 0.010° and in no instance was the sign of the difference between a sample and its check changed.

The arguments in this paper are in all cases based upon the comparison of the samples of abnormal fruits with their checks. The differences averaged and discussed in the text are in all cases taken as abnormal *less* control, the sign of the difference being positive when there is a greater depression of freezing point, higher osmotic pressure, or higher average molecular weight, in the abnormal fruits.

ANALYSIS OF DATA

The large table gives the essential constants for the various lots of fruits. The section to the left contains the data for the samples of abnormal fruits, that to the right those for the checks.

Consider first the properties of the juice in fruits differing only in the structure of the wall.

Series (*b*) and (*c*) may be regarded as transitions between the trimerous and tetramerous fruits.

In two cases Δ is higher and in one lower than in the control samples. The negative difference is only $-0.012°$ and is but twice or thrice the estimated experimental error. The mean difference in depression of the freezing point is $+0.035°$. The differences in pressure in atmospheres, P, have the same sign as the differences in depression. In one the difference is -0.144, in the other two it takes the more substantial values of $+0.638$ and $+1.143$; the mean of the three is $+0.546$. The average molecular weight is in all three cases lower in the abnormal fruits, -7.41, -4.46 and -9.02 being the values.

The tetramerous fruits (eight external sutures, four placentae, no prolification), class (*d*), are represented by nine samples, divided as follows:

	Positive differences	Negative differences	Mean value of differences
Δ	6	3	$+0.002°$ C.
M	2	7	-2.81
P	6	3	$+0.024$

Combining (*b*), (*c*) and (*d*), we have, with headings as above,

Δ	8	4	$+0.010°$ C.
M	2	10	-3.85
P	8	4	$+0.154$

TABLE I

PHYSICO-CHEMICAL CONSTANTS FOR JUICE OF NORMAL AND ABNORMAL PASSIFLORA FRUITS

Number of sample	Values for abnormal fruits					Values for normal controls.				
	Δ Depression of freezing point	$d\frac{20^\circ}{20^\circ}$ Specific gravity	s Solids in 100 c.c. of juice	M Molecular weight	P Osmotic pressure in atmospheres	Δ Depression of freezing point	$d\frac{20^\circ}{20^\circ}$ Specific gravity	s Solids in 100 c.c. of juice	M Molecular weight	P Osmotic pressure in atmospheres
1	0.503°	1.0161	3.042	115.95	6.061	0.515°	1.0169	3.349	124.97	6.205
2	0.593°	1.0191	3.466	112.23	7.144	0.540°	1.0173	3.282	116.69	6.506
3	0.633°	1.0195	3.600	109.26	7.626	0.568°	1.0180	3.448	116.67	6.483
4	0.405°	1.0122	2.209	104.10	4.881	0.358°	1.0114	2.162	115.35	4.315
5	0.503°	1.0163	3.065	116.86	6.061	0.428°	1.0129	2.356	105.14	5.157
6	0.525°	1.0174	2.630	95.54	6.326	0.513°	1.0171	2.720	101.21	6.181
7	0.435°	1.0146	2.282	99.98	5.242	0.511°	1.0168	2.747	102.70	6.157
8	0.587°	1.0187	3.381	110.53	7.071	0.618°	1.0202	3.567	110.79	7.445
9	0.558°	1.0175	3.102	106.52	6.729	0.543°	1.0169	3.233	114.27	6.542
10	0.585°	1.0181	3.154	103.29	7.047	0.581°	1.0183	3.091	101.81	7.000
11	0.567°	1.0161	3.478	118.13	6.831	0.608°	1.0195	3.907	123.87	7.324
12	0.539°	1.0169	3.204	114.10	6.494	0.527°	1.0167	3.270	119.18	6.349
13	0.673°	1.0219	4.237	121.45	8.107	0.614°	1.0184	3.526	110.38	7.397
14	0.573°	1.0188	2.857	95.12	6.903	0.550°	1.0186	2.798	97.07	6.627
15	0.705°	1.0243	4.290	117.18	8.492	0.628°	1.0212	3.652	111.62	7.565
16	0.603°	1.0200	3.540	112.70	7.264	0.613°	1.0184	3.212	100.42	7.384
17	0.569°	1.0184	3.696	125.10	6.855	0.554°	1.0183	3.523	122.26	6.674
18	0.708°	1.0189	3.891	106.01	8.528	0.683°	1.0202	4.172	117.95	8.227
19	0.558°	1.0195	——	——	6.723	0.585°	1.0204	——	——	7.048
20	0.643°	1.0203	3.729	111.51	7.746	0.597°	1.0185	3.354	107.79	7.192
21	0.455°	1.0149	——	——	5.483	0.548°	1.0180	——	——	6.603
22	0.577°	1.0180	3.584	119.53	6.952	0.533°	1.0170	3.598	130.07	6.422
23	0.563°	1.0178	3.281	111.83	6.783	0.599°	1.0198	3.754	120.60	7.216

Or disregarding the presence of prolification and adding to these the other fruits which are abnormal (tetramerous as contrasted with trimerous) in the organization of their ovary wall (i. e. classes (*g*), (*h*), and (*j*)), we get

Δ*.....	10	6	+ 0.008° C.
M.....	3	12	− 4.21
P.....	10	5	+ 0.151

Apparently, therefore, those fruits which are tetramerous or which show transitions between the trimerous and tetramerous condition, show a greater depression of the freezing point (and consequently a higher osmotic pressure) of their juice and a lower average molecular weight† than the trimerous ones. But the differences are so very slight, and the difficulties and sources of possible error are so many, that further studies will be required to put this conclusion on a sound basis.

Turn now from the classification of the fruits according to the characteristics of the ovary wall to a consideration of the question of prolification. Here classes (*b*), (*c*), (*d*) may be left entirely out of account.

First dividing the fruits that have prolifications into the classes, trimerous and tetramerous, with respect to the characteristics of the ovary wall, without regard to the size or the structure of the included body, we have the following:

For trimerous fruits (classes (*e*), (*f*) and (*i*)),

	Positive differences	Negative differences	Mean value of differences
Δ‡.....	5	2	+ 0.016° C.
M.....	4	2	+ 3.21
P.....	5	1	+ 0.417

For tetramerous fruits (classes (*g*), (*h*) and (*j*)),

* Depression of freezing point is available in one series in which the sample was lost before the total solids had been determined. Hence *M* and *P* are omitted.

† The average molecular weight does not necessarily take the same direction as the difference of the freezing points would indicate, inasmuch as colloids do not affect Δ but do influence the amount of total solids and through this the average molecular weight.

‡ The depression of the freezing point is available for one case for which *M* and *P* were not calculated, for the reason noted above.

Δ*	2	2	+ 0.002° C.
M	1	2	− 5.66
P	2	1	+ 0.141

On combining trimerous and tetramerous (as above) without regard to the character of the proliferous body we have:

Δ†	7	4	+ 0.011° C.
M	5	4	+ 0.25
P	7	2	+ 0.325

Apparently the proliferous fruits tend to show a greater depression of the freezing point and a higher osmotic pressure in their expressed juices than the normal checks with which they were compared. This is true for trimerous and tetramerous fruits alone and for the two classes taken together. Considering the fruits merely as normal and abnormal, we note that these results are in good agreement with those for fruits abnormal only in respect to the structure of the wall. For the trimerous fruits the results for *M* are, however, not in accord with those for fruits abnormal with respect to the wall only, *M* being higher in the abnormals than in the controls. For the tetramerous fruits the average molecular weight is again lower than in the controls. Taking both trimerous and tetramerous fruits (with prolifications) together, we find practically no difference between the average molecular weight of the fruits containing supernumerary carpels and that of their controls.

Let us now simply classify the fruits as normal and abnormal and compare the 23 samples abnormal in some character with their controls, which are normal in all regards. We have:

	Positive difference	Negative difference	Mean value of differences
Δ	15	8	+ 0.0107° C.
M	7	14	− 2.091
P	15	6	+ 0.2275

These results emphasize the conclusions drawn from the individual classes of fruits.

* Available for one case where *M* and *P* were not calculated.

† Available for two cases where *M* and *P* were not calculated.

DISCUSSION AND CONCLUSIONS

From the determination of the depression of the freezing point, the specific gravity, and the total solids in the expressed juice of 23 samples of abnormal fruits of *Passiflora gracilis* and a like number of controls, we are led to the following conclusions:

Our experiments indicate that the juice of abnormal fruits has a higher osmotic pressure (greater depression of the freezing point) than that of normals. This is true whether the abnormality be a meristic variation in the fruit wall—i. e. an increase in the number of external sutures or of the number of placentae over the normal condition—or the production of an entirely new structure in the form of an included whorl or whorls of accessory carpels springing from the floor of the fruit (prolification of the fruit).*

The average molecular weight of the substances in solution in the plant sap is, apparently, lower in the abnormal fruits, but this is less consistently true for the various classes of structural aberrations recognized.

While the findings are fairly consistent throughout, it must be remembered that the problem is surrounded with many difficulties. We have no desire to be dogmatic concerning these conclusions, realizing that a wider series of material than we could possibly obtain is desirable,† and that many questions remain to be investigated.‡ Furthermore, it is clear that the whole problem of the nature of the relationship between the structure of the fruits and the properties of the juice remains to be worked out. We only claim to have demonstrated that the physico-chemical properties of the plant sap deserve consideration as a first step in the analysis of the factors involved in morphological variations of the fruit.

STATION FOR EXPERIMENTAL EVOLUTION,
CARNEGIE INSTITUTION OF WASHINGTON.

* In a forthcoming memoir on the morphology of normal and teratological fruits of *Passiflora gracilis* one of us will show that the occurrence of prolification is to some degree correlated with abnormalities of the ovary wall.

† We hope another year to obtain a strain of plants showing a higher percentage of abnormalities or at least to obtain far larger series of dissections.

‡ In particular it will be of great interest to work out in detail the relationship between the properties of the juice of the ovary wall and that of the contained carpels in the case of fruits showing prolifications. Some beginning has been made on this problem, but as yet our data are too few to justify the discussion of this and several other points.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1912)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Includes several American species.

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A plant from South America?

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A native of Mexico.

Vol. 40 No. 2

BULLETIN

OF THE

TORREY BOTANICAL CLUB

FEBRUARY 1913

Studies on the Rocky Mountain flora—XXVIII

PER AXEL RYDBERG

FABACEAE

Thermopsis ovata (Robinson) Rydb.

Thermopsis montana ovata Robinson, Contr. U. S. Nat. Herb. 11: 349. 1906.

This differs from *T. montana* not only in its broader leaflets (the only characters given in the original description) but in its spreading leaves, its large stipules, which in the lower leaves are ovate and very oblique, and in its elongate and lax raceme. It differs from *T. xylorrhiza* A. Nels. in its lax inflorescence and strictly straight pods.

Dr. S. Watson in publishing *Lupinus Kingii* described the plant as being perennial. This mistake of his led him as well as others astray, for he redescribed the same plant a few years later as an annual under the name *L. Sileri*. This fact has been called attention to several times and, among other places, in my Flora of Colorado. It is, therefore, surprising that the error should be repeated by Coulter and Nelson in the New Manual of Botany of the Central Rocky Mountains, where the description begins: "From a perennial rootstock, dwarf, cespitose," etc., characters which in no way apply to the type in the Gray Herbarium nor to the duplicates in the herbaria of Columbia University and the United States National Museum. Furthermore, Coulter and

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Nelson give as a synonym under the same *Lupinus aduncus* Greene, which is the same as *L. argenteus argophyllus*, a plant of different habit.

The so-called *Lupinus rivularis* of the Columbia region and extending into Idaho should be known as *L. cytisoides* Agardh. Miss Alice Eastwood has seen the type of *L. rivularis* Dougl., which according to her belongs to an entirely different group from the plant called *L. rivularis* by Dr. Watson in his revision.

The following Lupines are to be added to the flora of the Rocky Mountains: *Lupinus nootkatensis* Donn has been collected in the Rockies of British Columbia and Alberta, *L. plumosus* Dougl. in Idaho and Utah, *L. minimus* Dougl. in Idaho and Alberta, *L. lepidus* Dougl. in Idaho, *L. Cusickii* S. Wats. in Idaho and Utah, and *L. micensis* Jones in Utah.

Lupinus lupinus Rydb. sp. nov.

Perennial with a woody caudex; stems 3–6 dm. high, densely strigose-canescent, sparingly branched; leaves numerous; stipules subulate, about 1 cm. long; petioles canescent, 5–8 cm. long; leaflets 7–9, oblanceolate, usually flat, 3–6 cm. long, appressed-canescent on both sides, less so above; peduncles about 1 dm. long; raceme 5–10 cm. long; bracts lanceolate, acute, 3–4 mm. long, silvery-pubescent, early deciduous; calyx silvery-pubescent, saccate at the base; upper lip scarcely 3 mm. long, the lower fully 5 mm.; corolla about 1 cm. long, dark blue or purple; banner orbicular, pubescent on the back, usually with a light spot in the center; keel strongly curved, rather broad, ciliate on the margins; pod densely villous, about 3 cm. long, mostly 3-seeded.

This is related to *L. argentinus*, *L. aduncus*, and *L. oreophilus*, but differs from the first in its grayish instead of silvery pubescence of the leaves, which are greener above and not conduplicate, and in its less spurred calyx; from *L. aduncus* in its broader leaves and the shorter upper lip of its calyx; and from *L. oreophilus* in its broader leaves and saccate calyx.

Along streams and in meadows at an altitude of 2,000–3,000 m.

UTAH: Western Bear's Ear, Elk Mountains, Aug. 2, 1911, *Rydberg & Garrett 9363* (type, in herb. N. Y. Bot. Gard.); also western slope of La Sal Mountains, July 6, *8595*, *8596*, and *8600;* meadow south of Monticello, July 24, *9167;* Head of Dry Wash,

Abajo Mountains, August 11, *9605;* Hammond Canyon, Elk Mountains, August 10, *9583*.

LOTUS TENUIS Waldst. & Kit.; Willd. Enum. Hort. Berol. 797. 1809

Lotus tenuifolius (L.) Reich. Fl. Germ. 506. 1830.
Lotus Macbridei A. Nels. Bot. Gaz. **53**: 221. 1912.

In looking over a collection received in exchange from the University of Wyoming, I found a specimen labeled *Lotus Macbridei* A. Nels. n. sp. To my surprise I found that this was a true *Lotus*, i. e. not belonging to any of the segregates of *Hosackia* but of the European type. As it would have been exceedingly strange if a species of *Lotus* in the restricted sense should be found native in America, I turned to our collection of Old World species of *Lotus* and found that it is the same as *L. tenuifolius* (L.) Reich. Before I had time to call Professor Nelson's attention to the fact, his description appeared in the Botanical Gazette.

Trifolium macrocephalum (Pursh) Piper, *T. plumosum* Dougl., *T. eriocephalum* Nutt., *T. spinulosum* Dougl., and *cyathiferum* Lindl. have been collected in Idaho; *T. Rusbyi* Greene and *Medicago hispida* Gaertner (*M. denticulata* Willd.) in Montana.

ACMISPON Raf. New Flora **1**: 53. 1836

I think that this genus should be restored. The *Microlotus* section sometimes referred to *Hosackia*, sometimes to *Lotus*, is out of place in either genus, and *Acmispon* is the oldest available generic name.

Acmispon americanus (Nutt.) Rydb.

Lotus sericeus Pursh, Fl. Am. Sept. 489. 1814. Not *L. sericeus* DC. 1813.
Trigonella americana Nutt. Gen. **2**: 120. 1818.
Hosackia Purshiana Benth. Bot. Reg. under *pl. 1257*. 1829.
Acmispon sericeum Raf. New Fl. **1**: 53. 1836.
Lotus americanus Bisch. Del. Sem. Hort. Heidelb. 1839.
Trigonella sericea Eat. & Wright, N. Am. Bot. Ed. 8, 459. 1840.

Acmispon elatus (Nutt.) Rydb.

Hosackia elata Nutt.; T. & G. Fl. 1: 327. 1838.

The former of the two species is common on the plains from Minnesota to Arkansas, Sonora, and Idaho; the latter is found in Washington, Oregon, and Idaho. A few more species are found in California.

Psoralea stenostachys Rydb. sp. nov.

Perennial with a horizontal rootstock; stem adsurgent or erect, branched, sparingly strigose and glandular-dotted, 3–5 dm. high; leaves digitately 3-foliolate; leaflets oblanceolate, 2–4 cm. long, from rounded to acute at the base, mucronate at the apex, sparingly strigose and conspicuously glandular-punctate; peduncles 5–15 cm. long; racemes elongate, many-flowered and lax: calyx densely white-strigose; tube 1.5 mm. long; teeth 0.5 mm. long, lanceolate or lance-ovate, acute; corolla white, 4 mm. long; pod densely white-hairy.

This species is related to *P. lanceolata* Pursh and *P. Purshii* Vail, but differs from both in the elongate racemes and the acute calyx-lobes; from the former it differs also in the hairy pod, and from the latter in the narrower leaflets. It grows on sandy soil at an altitude of about 1,300–1,500 m.

UTAH: Government Well, Toole County, June 7, 1900, *M. E. Jones 6221* (type, in herb. N. Y. Bot. Gard.); Utah, July 2, 1888, *M. E. Jones 1833*.

Psoralea stenophylla Rydb. sp. nov.

Perennial with a horizontal rootstock; stem simple, about 5 dm. high, slender, sparingly strigose and glandular-punctate; leaves digitately 3-foliolate or the lower 5-foliolate; leaflets narrowly linear, 2.5–5 cm. long, about 2 mm. wide, glandular-punctate and sparingly strigose; stipules linear, 5–8 mm. long; petioles about 3 cm. long; peduncles 8–10 cm. long; racemes elongate, 5 cm. long or longer, lax; pedicels usually longer than the calyx; calyx sparingly strigose, conspicuously punctate; lobes triangular, acute, 0.5 mm. long; corolla about 4 mm. long; fruit not seen.

This has the narrow leaflets of *Psoralea micrantha*, but the raceme is elongate and the sepals are acute as in the preceding species, from which it differs in the very narrow leaflets. If it has the densely hairy pod of that species and *P. Purshii*, it cannot be told from the material, but the young ovaries do not indicate

such a character. It grows on sandy river banks at an altitude of about 1,600 m.

UTAH: Proposed dam site, near Wilson Mesa, Grand County, July 1, 1911, *Rydberg & Garrett 8367* (type, in herb. N. Y. Bot. Gard.).

Psoralea juncea Eastw. was described as being leafless, the leaves being reduced to scales. This is true as far as the stem-leaves are concerned. The basal leaves, which soon wither away, are digitately 3–5-foliolate with lanceolate leaflets, 2–3 cm. long, grayish, strigose and strongly veiny.

Psoralea obtusiloba Torrey has been collected in Colorado by Tweedy.

Parosela polydenia (Torr.) Heller, *P. Fremontii* (Torr.) Vail, *P. Johnsoni* (S. Wats.) Vail, and *P. amoena* (S. Wats.) Vail have been collected in southern Utah.

Phaca ampullaria (S. Wats.) Rydb.

Astragalus ampullarius S. Wats. Am. Nat. **7**: 300. 1873.

Phaca Wardii (A. Gray) Rydb.

Astragalus Wardii A. Gray, Proc. Am. Acad. **12**: 55. 1877.

Phaca subcinerea (A. Gray) Rydb.

Astragalus subcinereus A. Gray, Proc. Am. Acad. **13**: 366. 1878.

Phaca Cusickii (A. Gray) Rydb.

Astragalus Cusickii A. Gray, Proc. Am. Acad. **13**: 370. 1878.

Phaca sabulonum (A. Gray) Rydb.

Astragalus sabulonum A. Gray, Proc. Am. Acad. **13**: 368. 1878.

Phaca Preussii (A. Gray) Rydb.

Astragalus Preussii A. Gray, Proc. Am. Acad. **6**: 222. 1864.

Phaca serpens (M. E. Jones) Rydb.

Astragalus serpens M. E. Jones, Proc. Cal. Acad. II. **5**: 641. 1895.

Phaca Silerana (M. E. Jones) Rydb.

Astragalus Sileranus M. E. Jones, Zoe **2**: 242. 1891.

Phaca jejuna (S. Wats.) Rydb.

Astragalus jejunus S. Wats. Bot. King Exped. 73. 1871.

Phaca leptalea (A. Gray) Rydb.

Phaca pauciflora Nutt.; T. & G. Fl. N. Am. 1: 348, 1838. Not *P. pauciflora* Pers. 1806.

Astragalus leptaleus A. Gray, Proc. Am. Acad. 6: 220. 1864.

Phaca artemisiarum (M. E. Jones) Rydb.

Astragalus Beckwithii purpureus M. E. Jones, Zoe 3: 288. 1893. Not *A. purpureus* Lam. 1783.

Astragalus artemisiarum M. E. Jones, Zoe 4: 369. 1894.

Phaca pubentissima (T. & G.) Rydb.

Astragalus multicaulis Nutt.; T. & G. Fl. N. Am. 1: 335. 1838. Not *A. multicaulis* Ledeb. 1831.

Astragalus pubentissimus T. & G. Fl. N. Am. 1: 693. 1840.

Mr. Sheldon placed this between *Astragalus crescenticarpus* and *A. cibarius*, two species of *Xylophacos;* its pod is that of a *Phaca.*

Phaca sesquiflora (S. Wats.) Rydb.

Astragalus sesquiflorus S. Wats. Proc. Am. Acad. 10: 346. 1875.

Mr. Sheldon associated this erroneously with *Astragalus vexilliflexus* and other species of *Homalobus.* It is a true *Phaca.*

Xylophacos cuspidocarpus (Sheld.) Rydb.

Astragalus cuspidocarpus Sheld. Minn. Bot. Stud. 1: 147. 1894.

Xylophacos cibarius (Sheld.) Rydb.

Astragalus cibarius Sheld. Minn. Bot. Stud. 1: 149. 1894.

Astragalus arietinus M. E. Jones, Proc. Calif. Acad. II. 5: 653. 1895.

Xylophacos puniceus (Osterh.) Rydb.

Astragalus puniceus Osterh. Muhlenbergia 1: 140. 1906.

Xylophacos Zionis (M. E. Jones) Rydb.

Astragalus Zionis M. E. Jones, Proc. Calif. Acad. II. 5: 652. 1895.

Xylophacos argophyllus (Nutt.) Rydb.

Astragalus argophyllus Nutt.; T. & G. Fl. N. Am. 1: 331. 1838.

Xylophacos cymboides (M. E. Jones) Rydb.

Astragalus cymboides M. E. Jones, Proc. Calif. Acad. II. 5: 650. 1895.

Xylophacos musinensis (M. E. Jones) Rydb.

Astragalus musinensis M. E. Jones, Proc. Calif. Acad. II. 5: 671. 1895.

Xylophacos consectus (Sheld.) Rydb.

Astragalus consectus Sheld. Minn. Bot. Stud. 1: 143. 1894.

Xylophacos Watsonianus (Kuntze) Rydb.

Astragalus eriocarpus S. Wats. Bot. King Exped. 71. 1871. Not *A. eriocarpus* DC. 1802.

Tragacantha Watsoniana Kuntze, Rev. Gen. Pl. 2: 942. 1891.

Astragalus Watsonianus Sheld. Minn. Bot. Stud. 1: 144. 1894.

Xylophacos utahensis (Torr.) Rydb.

Phaca mollissima utahensis Torr. Stansb. Exped. 385. 1852.

Astragalus utahensis T. & G. Pac. R. Rep. 2: 120. 1855.

Xylophacos inflexus (Dougl.) Rydb.

Astragalus inflexus Dougl. in G. Don, Gen. Syst. 2: 256. 1832.

Tium eremiticum (Sheld.) Rydb.

Astragalus eremiticus Sheld. Minn. Bot. Stud. 1: 161. 1894.

Tium atropubescens (Coult. & Fish.) Rydb.

Astragalus atropubescens Coult. & Fish. Bot. Gaz. 18: 300. 1893.

Astragalus Kelseyi Rydb. Mem. N. Y. Bot. Gard. 1: 241. 1900.

Tium arrectum (A. Gray.) Rydb.

Astragalus arrectus A. Gray, Proc. Am. Acad. 8: 289. 1873.

Astragalus Leibergii M. E. Jones, Proc. Calif. Acad. II. 5: 663. 1895.

Astragalus palousiensis Piper, Bot. Gaz. 22: 489. 1896.

Hamosa calycosa (Torr.) Rydb.

Astragalus calycosus Torr. in S. Wats. Bot. King Exped. 66. 1871.

Ctenophyllum Grayi (Parry) Rydb.

Astragalus Grayi Parry; Wats. Am. Nat. **8**: 212. 1874.

Cystium platytropis (A. Gray) Rydb.

Astragalus platytropis A. Gray, Proc. Am. Acad. **6**: 526. 1865.

Cystium Coulteri (Benth.) Rydb.

Astragalus Coulteri Benth. Pl. Hartw. 307. 1848.

Cystium ineptum (A. Gray) Rydb.

Astragalus ineptus A. Gray, Proc. Am. Acad. **6**: 525. 1865.

Cystium lentiginosum (Dougl.) Rydb.

Astragalus lentiginosus Dougl.; Hook. Fl. Bor.-Am. **1**: 151. 1831.

Cystium araneosum (Sheld.) Rydb.

Astragalus araneosus Sheld. Minn. Bot. Stud. **1**: 170. 1894.

Cystium boiseanum (A. Nels.) Rydb.

Astragalus boiseanus A. Nels. Bot. Gaz. **53**: 223. 1912.

Atelophragma lineare Rydb. sp. nov.

Homalobus aboriginum Rydb. Bull. N. Y. Bot. Gard. **2**: 176, in part. 1901.

Perennial with a woody taproot and short cespitose caudex; stem grayish strigose, often tinged with purple, 2–4 dm. high; stipules ovate or lanceolate, acute, 2–4 mm. long; leaves 5–6 cm. long; leaflets 9–15, linear, 1–2 cm. long, 1–2 mm. wide, grayish strigose; peduncles 5–10 cm. long; raceme 2–3 cm. long, in fruit 6 cm. long; calyx densely black-hairy; tube 3 mm. long; teeth subulate, 2 mm. long; corolla about 8 mm. long, ochroleucous or tinged with purple; keel tipped with dark purple; legume glabrous, stipitate; stipe 4–5 mm. long; body 25–28 mm. long, convexly curved on both sutures, but much more strongly so on the upper; the partial partition very narrow.

This is related to *A. glabriusculum* (A. Gray) Rydb. and *A. aboriginum* (Richardson) Rydb., but differs from the former in the

grayish pubescence of the leaves, which are strigose instead of villous, and from both in the form of the pod. In both the lower suture of the pod is straight or slightly concavely curved.

YUKON TERRITORY: Foot of Lake Lebarge, 1899, *J. B. Tarleton 34b* (type, in herb. N. Y. Bot. Gard.); Dry Gulch, 1899, *Gorman 1014.*

ALBERTA: Rocky Mountains, 1857–1859, *Bourgeau.*

Atelophragma Forwoodii (S. Wats.) Rydb.

Astragalus Forwoodii S. Wats. Proc. Am. Acad. **25**: 129. 1890.

Sheldon places this species in the *Homalobus*, but it is closely related to *Atelophragma aboriginum* and *A. glabriusculum.*

Atelophragma glabriusculum (Hook.) Rydb.

Phaca glabriuscula Hook. Fl. Bor.-Am. **1**: 144. 1831.

Atelophragma ibapense (M. E. Jones) Rydb.

Astragalus ibapense M. E. Jones, Zoe **3**: 290. 1893.

Atelophragma Arthuri (M. E. Jones) Rydb.

Astragalus Arthuri M. E. Jones, Cont. West. Bot. **8**: 20. 1898.

Onix Mulfordae (M. E. Jones) Rydb.

Astragalus Mulfordae M. E. Jones, Cont. West. Bot. **8**: 18. 1898.

This species is the only representative in America of a group of plants segregated from *Astragalus* by Medicus. The other representatives are Asiatic. *Onix* is related to *Cystium* in having a membranous inflated 2-celled pod, but the pod is triangular in cross-section, the upper suture being acute and the lower more or less sulcate.

Microphacos parviflorus (Pursh) Rydb.

Dalea parviflora Pursh, Fl. Am. Sept. 474. 1814.

Astragalus gracilis Nutt. Gen. **2**: 100. 1818.

Phaca parviflora Nutt.; T. & G. Fl. N. Am. **1**: 348. 1838.

Diholcos scobinatulus (Sheld.) Rydb.

Astragalus Haydenianus major M. E. Jones, Zoe **2**: 241. 1891.

Astragalus Haydenianus nevadensis M. E. Jones, Zoe **2**: 241. 1891.

Astragalus scobinatulus Sheld. Minn. Bot. Stud. **1**: 24. 1894.

Phacopsis scaphoides (M. E. Jones) Rydb.

Astragalus arrectus scaphoides M. E. Jones, Proc. Calif. Acad. II. **5**: 664. 1895.

Cnemidophacos confertiflorus (A. Gray) Rydb.

Astragalus confertiflorus A. Gray, Proc. Am. Acad. **13**: 368. 1878.

Cnemidophacos argillosus (M. E. Jones) Rydb.

Astragalus argillosus M. E. Jones, Zoe **2**: 241. 1891.

Cnemidophacos reventoides (M. E. Jones) Rydb.

Astragalus reventoides Jones, Proc. Calif. Acad. II. **5**: 661. 1895.

Cnemidophacos reventus (A. Gray) Rydb.

Astragalus reventus A. Gray, Proc. Am. Acad. **15**: 46. 1880.

Kentrophyta tegetaria (S. Wats.) Rydb.

Astragalus tegetarius S. Wats. Bot. King Exped. 76. 1871.

Homalobus lingulatus (Sheld.) Rydb.

Astragalus lingulatus Sheld. Minn. Bot. Stud. **1**: 118. 1894.

Homalobus exilifolius (A. Nels.) Rydb.

Astragalus exilifolius A. Nels. Bull. Torrey Club **26**: 10. 1899.

Homalobus simplicifolius (Nutt.) Rydb.

Phaca simplicifolia Nutt.; T. & G. Fl. N. Am. **1**: 350. 1838.
Astragalus simplicifolius A. Gray, Proc. Am. Acad. **6**: 231. 1864.

Homalobus lancearius (A. Gray) Rydb.

Astragalus lancearius A. Gray, Proc. Am. Acad. **13**: 370. 1878.

Homalobus miser (Dougl.) Rydb.

Astragalus miser Dougl.; Hook. Fl. Bor.-Am. **1**: 153. 1831.

Homalobus Dodgeanus (M. E. Jones) Rydb.

Astragalus Dodgeanus M. E. Jones, Zoe **3**: 289. 1893.

Mr. Sheldon placed this next to *Astragalus glabriusculus* (Hook.) Gray, but its pod has not a trace of a partition and the plant is a true *Homalobus*, not an *Atelophragma*.

Homalobus debilis (Nutt.) Rydb.

Phaca debilis Nutt.; T. & G. Fl. N. Am. 1: 345. 1838.
Astragalus debilis A. Gray, Proc. Acad. Sci. Phila. 1863: 60. 1864.

Homalobus strigosus (Coult. & Fish.) Rydb.

Astragalus strigosus Coult. & Fish. Bot. Gaz. **18**: 299. 1893.
Astragalus griseopubescens Sheld. Minn. Bot. Stud. 1: 24. 1894.

Homalobus episcopus (S. Wats.) Rydb.

Astragalus episcopus S. Wats. Proc. Am. Acad. **10**: 346. 1875.

Homalobus collinus (Dougl.) Rydb.

Phaca collina Dougl.; Hook. Fl. Bor.-Am. 1: 141. 1831.
Astragalus collina Dougl.; G. Don, Gen. Syst. **2**: 256. 1832.

Aragallus Bigelovii (A. Gray) Rydb.

Oxytropis Lambertii Torr. Pac. R. Rep. **4**: 80. 1857. Not *O. Lambertii* Pursh. 1814.
Oxytropis Lambertii Bigelovii A. Gray, Proc. Am. Acad. **20**: 7. 1885.

Aragallus plattensis (Nutt.) Rydb.

Oxytropis plattensis Nutt.; T. & G. Fl. N. Am. 1: 340. 1838.

Lathyrus graminifolius White and *L. Torreyi* A. Gray have been collected in southern Utah; *L. Nuttallii* S. Wats. and *L. obovatus* White in Idaho.

EUPHORBIACEAE

Chamaesyce Parryi (Engelm.) Rydb.

Euphorbia Parryi Engelm. Am. Nat. **9**: 350. 1875.
This has been collected in southern Utah.

Chamaesyce exstipulata (Engelm.) Rydb.

Euphorbia exstipulata Engelm. Bot. Mex. Bound. Surv. 189. 1859.
Euphorbia Aliceae A. Nels. Bot. Gaz. **42**: 50. 1906.
This has been collected as far north as Wyoming.

ACERACEAE

NEGUNDO (Ray) Ludwig-Boehmer, Def. Pl. 508. 1760

Professor Nieuwland in the American Midland Naturalist* discussed the North American species of box-elder. He used the name *Rulac*, believing in a pre-Linnaean priority for genera. As both the Vienna Rules and the American Code have adopted 1753 as the starting point for botanical nomenclature, few will follow him in the names adopted. If our box-elders are regarded as generically distinct from the maples, we must use the name *Negundo*. Professor Nieuwland recognizes six species. I think there should be recognized eight species in North America. The Texan form, *Rulac californica texana* Pax, is well distinct from *Negundo californicum*, Professor Nieuwland having overlooked the difference in the fruit, which in the Texan species agrees more with our eastern box-elder and was included in it by Dr. Britton. The following key was prepared by me over two years ago and two new species were named in manuscript. One of these has been described by Professor Nieuwland under the name *Rulac Nuttallii;* a description of the other is given below. I publish here the key, as several of the characters have not been pointed out by Professor Nieuwland.

Branches of the season glabrous or with a few scattered appressed hairs; anthers acute, tapering into a tip ¼–⅓ mm. long, formed by the produced connective (in the first species unknown).

Fruiting pedicels glabrous, the lower 5–8 cm. long, very slender: fruit glabrous, contracted below into a short stipe. 1. *N. orizabense.*

Fruiting pedicels sparingly pilose: the lower 2–3 cm. long.

Ovary and fruit finely pubescent; the latter sometimes becoming glabrate in age, distinctly constricted below into a narrow stipe-like base; leaflets broad, toothed, rarely lobed. 2. *N. Negundo.*

Ovary and fruit glabrous; the latter slightly or usually not at all constricted below; leaflets usually lobed, with hair-tufts in the axils of the veins. 3. *N. Nuttallii.*

Branches of the season densely velutinous with short spreading hairs; anthers obtuse, merely mucronate.

Leaflets coarsely dentate or lobed; style evident but short.

Fruit distinctly constricted at the base into a short stipe, densely and minutely pubescent; leaflets

* Vol. 2: 129–140. 1911.

broadly oval, short-acuminate, usually merely dentate; the lateral ones often oblique at the base. 4. *N. texanum*

Fruit not at all or slightly constricted at the base; leaflets lanceolate, ovate or obovate, or the terminal one rhombic, long-acuminate, usually more or less lobed.

Fruit glabrous or with a few scattered hairs, similar to those of the pedicels; mucro of the anthers minute or obsolete; leaflets glabrate above in age.

Racemes seldom more than 1 dm. long; wings scarcely at all decurrent on the body of the fruit. 5. *N. interius.*

Racemes in fruit 1.5–2 dm. long; wings decurrent on the body of the fruit almost to the bottom of the sinus. 6. *N. Kingii.*

Fruit densely puberulent; mucro of the anthers more distinct, nearly ¼ mm. long; leaflets densely pubescent on both sides. 7. *N. californicum.*

Leaflets sharply and evenly serrate except towards the base; style obsolete. 8. *N. mexicanum.*

1. **Negundo orizabense** Rydb. sp. nov.

A tree with glabrous, brownish twigs; leaves 3-foliolate; pedicels slender, glabrous, 5–10 cm. long; leaflets thin, glabrous or with a few scattered hairs on the ribs below, acuminate at both ends, serrate above the middle, with broadly ovate teeth directed forward and mucronate; the terminal leaflet rhombic-oval, 5–10 cm. long, with petiolules 1–2 cm. long; the lateral ones lanceolate, oval or oblanceolate, short-petioluled; racemes in fruit 2 dm. long or more, the pedicels very long and slender, the lower 5–8 cm. long; samaras ascending, glabrous; body oblong, about 1 cm. long and 4 mm. wide, acute but not constricted at the base, with one strong and several weak longitudinal veins; wing about 2 cm. long and nearly 1 cm. wide, somewhat incurved above, not decurrent on the body.

MEXICO: Orizaba, 1853 and 1855, *Fred. Müller* (type, in herb. Columbia University).

2. **Negundo Negundo** (L.) Karsten, Deuts. Fl. 596. 1880–3*

DISTRIBUTION: From Ontario and Vermont to Georgia, Missouri and Illinois.

3. **Negundo Nuttallii** (Nieuwl.) Rydb.

Acer fraxinifolium Nuttall, Gen. N. Am. 1: 253. 1818. Not *Negundium fraxinifolium* Raf. 1808.

* For other synonyms see Nieuwland, American Midland Naturalist 2: 136. 1911.

Rulac Nuttallii Nieuwl. Am. Midl. Nat. **2**: 137. 1911.

DISTRIBUTION: From Michigan and Ohio (?) to Kansas, Colorado and Montana.

4. **Negundo texanum** (Pax) Rydb.

Acer Negundo texanum Pax; Bot. Jahrb. **7**: 212. 1886.
Acer californicum texanum Pax; Bot. Jahrb. **11**: 75. 1889.
Rulac texana Small, Fl. SE. U. S. 743. 1903.

DISTRIBUTION: Texas and Oklahoma.

5. **Negundo interius** (Britton) Rydb.

Rulac texana Small, Fl. SE. U. S. 743, in part. 1903. Not *Acer texanum* Pax. 1886.
Acer interior Britton, N. Am. Trees 655. 1908.

DISTRIBUTION: From Saskatchewan and Manitoba to Nebraska, New Mexico, Arizona and Montana. Nieuwland gives *Negundo Fraxinus* Bourgeau* as a synonym under this. At the place referred to Bourgeau enumerates a number of genera collected on May 6. Evidently a comma is omitted between *Negundo* and *Fraxinus*.

6. **Negundo Kingii** (Britton) Rydb.

Acer Kingii Britton, N. Am. Trees 656. 1908.
Rulac Kingii Nieuwl. Am. Midl. Nat. **2**: 139. 1911.

DISTRIBUTION: Utah and Arizona.

7. NEGUNDO CALIFORNICUM T. & G. Fl. N. Am. **1**: 250. 1838

Acer californicum Dietr. Syn. **2**: 1283. 1840.
Rulac californica Nieuwl. Am. Midl. Nat. **2**: 139. 1911.

DISTRIBUTION: California and according to Nieuwland extending into northern Mexico.

8. NEGUNDO MEXICANUM DC. Prod. **1**: 546. 1824

Acer mexicanum Pax; Bot. Jahrb. **7**: 212. 1886. Not *Acer mexicanum* A. Gray. 1861.
Rulac mexicana Nieuwl. Am. Midl. Nat. **2**: 140. 1911.

DISTRIBUTION: Southern Mexico to Guatemala.

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* Journ. Linn. Soc. **4**: 9. 1859.

RHAMNACEAE

Rhamnus betulaefolia Greene is to be added to the flora; it was collected in southeastern Utah in the summer of 1911 by Professor Garrett and myself.

MALVACEAE

Dr. Greene* in segregating *Eremalche* from *Malvastrum* made this statement: "and that there exists so much as one real *Malvastrum* north of the Mexican border, I hold to be doubtful."

A little investigation in the history of the genus would show that this statement is untenable. It is evident that Dr. Gray did not base his conception of the genus *Malvastrum* on the section *Malvastrum* of *Malva* of De Candolle, for this section contains the typical species of *Malva* also.

The first subsection of this section of De Candolle's is *Chrysanthae*, and some species of this subsection must be regarded as the type of *Malva* section *Malvastrum* DC. Of this subsection Dr. Gray remarked: "If the yellow flowered species with a somewhat different habit and usually a manifest persistent involucre, which forms a second section (the *Chrysanthae* DC., etc.), are correctly referred to this genus, it will comprise a large number of species from tropical and South America, which need an elaborate revision. I enumerate below merely the North American species which are known to me." Furthermore, Dr. Gray did not include in his genus a single species of *Malva* given by De Candolle. This shows that Dr. Gray based his genus on the North American species and in publishing the genus he gave the name as "MALVASTRUM *Nov. Gen.*," without citing De Candolle's section, although he had referred to it a few pages before in a footnote under *Callirrhoe*. As the type of the genus *Malvastrum*, therefore, we must desigate the first given binomial under *Malvastrum*, which is *M. coccineum*. Of the other species included in the original publication *M. Fremontii* Torr., *M. Wrightii* A. Gray, *M. grossulariaefolium* (Hook.) A. Gray, *M. angustum* A. Gray, *M. Munroanum* (Dougl.) Gray, and *M. spicatum* (L.) Gray are plants of the United States. I agree with Dr. Greene that *M. rotundifolium* A. Gray and *M. exile* A. Gray should not be included in *Malvas-*

* Leaflets 1: 207. 1906.

trum; but I believe that that genus should be merged in *Sphaeralcea*. *Malvastrum coccineum*, the type of the genus, has the habit of the typical species of *Sphaeralcea*. The fruit is also the same except that the empty non-reticulate portion of the carpel is much reduced. *M. grossulariaefolium* and *M. Munroanum* with little more developed upper portions have been tossed back and forth between the genera *Malvastrum* and *Sphaeralcea*. Six species should be transferred from *Malvastrum* to *Sphaeralcea* under the following names.

Sphaeralcea grossulariaefolia (H. & A.) Rydb.

(?) *Malva Creeana* Graham, Bot. Mag. *pl. 3698*. 1838.
Sida grossulariaefolia Hook. & Arn. Bot. Beech. Voy. 326. 1841.
Malvastrum grossulariaefolium A. Gray, Mem. Am. Acad. 4: 21. 1849.
Sphaeralcea pedata Torr. Mem. Am. Acad. 4: 23. 1849.
Malvastrum coccineum grossulariaefolium Torr. Stansb. Exped. 384. 1852.

Sphaeralcea dissecta (Nutt.) Rydb.

Sida dissecta Nutt.; T. & G. Fl. N. Am. 1: 235. 1838.
Malvastrum coccineum dissectum A. Gray, Pl. Wright. 1: 17, in part. 1852.

Sphaeralcea coccinea (Nutt.) Rydb.

Malva coccinea Nutt. Fras. Cat. 1813.
Cristaria coccinea Pursh, Fl. Am. Sept. 454. 1814.
Sida coccinea DC. Prod. 1: 465. 1824.
Malvastrum coccineum A. Gray, Mem. Am. Acad. 4: 21. 1849.

Sphaeralcea elata (E. G. Baker) Rydb.

Malvastrum coccineum elatum E. G. Baker, Jour. Bot. 29: 171. 1891.
Malvastrum elatum A. Nels. Bot. Gaz. 34: 25. 1902.

Sphaeralcea digitata (Greene) Rydb.

Malvastrum coccineum dissectum A. Gray, Pl. Wright. 1: 17, in part. 1852.
Sphaeralcea pedata angustiloba A. Gray, Proc. Am. Acad. 22: 292. 1887.

Malvastrum digitatum Greene, Leaflets 1: 154. 1905.
Malvastrum dissectum Cockerell, Bull. Torrey Club 27: 87, mainly. 1900.
Malvastrum Cockerellii A. Nels. Bot. Gaz. 34: 24. 1902.
Malvastrum dissectum Cockerellii A. Nels.; Coult. & Nels. New Man. Bot. Cent. Rocky Mts. 318. 1909.

Sphaeralcea leptophylla (A. Gray) Rydb.

Malvastrum leptophyllum A. Gray, Pl. Wright. 1: 17. 1852.

Sphaeralcea arizonica Heller, sp. nov.

Perennial with a woody caudex branching from the base; leaf-blades reniform to cordate, 3–5 cm. long, densely stellate on both sides, obscurely lobed and crenate; inflorescence paniculate, dense, with short branches; calyx densely stellate throughout; its lobes ovate, acute, about 3 mm. long; petals pink, about 1 cm. long; carpels about 4 mm. long and 1.5 mm. wide, mucronate or short-cuspidate, oblong, only about the lowest fourth reticulate.

Differing from *S. ambigua* in the short calyx-lobes and the narrow and dense inflorescence and from *S. marginata* in the dense stellate pubescence, which extends even to the calyx.

ARIZONA: Flagstaff, June 16, 1898, *MacDougal 120* (type, in herb. N. Y. Bot. Gard.); 30 miles east of Flagstaff, July 18, 1893. *Wooton;* Fort Verde, May 4, 1888, *Mearns 225;* same locality 1887, *150*; Holbrook, June 18, 1901, *L. F. Ward;* Ash Fork, June 10, 1883, *Rusby 538.*

UTAH: St. George, Apr. 14, 1880, *M. E. Jones 1660;* proposed dam site, near Wilson Mesa, Grand Co., July 1, 1911, *Rydberg & Garrett 8386;* S. Utah, 1877, *Palmer;* 1874, *Parry 25.*

Sphaeralcea subrhomboidea Rydb. sp. nov.

Perennial with a woody caudex, branched at the base; stems stellate, 2–4 dm. high; leaf-blades rhombic in outline, 2–5 cm. long, stellate but not densely so, grayish-green, cuneate at the base, 5-ribbed, 3-cleft about half way down, the divisions 2–4-lobed; inflorescence a dense virgate panicle; calyx densely stellate, 4–5 mm. long; lobes broadly ovate, obtusish; corolla scarlet, 8–9 mm. long; fruit depressed-globose; carpels nearly round, obtuse, the lower half reticulate on the faces; seed solitary, without filiform attachment.

Nearest related to *S. grossulariaefolia* but the leaf-blades are rhombic in outline and cleft only half way down, and the terminal lobe is decidedly acute. On account of the leaf-form it may be mistaken for *S. Munroana*, but the flowers are smaller, the leaves more deeply divided, the fruit is smaller, the carpels less reniform, and the seed without filiform attachment.

UTAH: Wahsatch County, near Midway, July 6, 1905, *Carlton & Garrett 6691* (type, in herb. N. Y. Bot. Gard.); Fish Lake, around Twin Creeks, Aug. 8, 1905, *Rydberg & Carlton 7627*.

There is a group of plants in *Sphaeralcea*, however, which differs from the rest not only in habit but also in the character of the fruit. The carpels are not, as in the typical *Sphaeralcea*, divided into a lower portion, reticulate on the faces and enclosing the seeds, and an upper smooth and empty portion; the whole carpel is in this group smooth and hirsute. Dr. Greene* took out this group and made a new genus under the name of *Illiamna*. I think that this was unnecessary, for the plants are evidently cogeneric with the West Indian *Phymosia*, usually also merged in *Sphaeralcea*. If the two genera should be merged, the name for the genus would be *Phymosia*, for it is the older of the two. The species to be renamed under *Phymosia* are the following:

Phymosia acerifolia (Nutt.) Rydb.

Sphaeralcea acerifolia Nutt.; T. & G. Fl. N. Am. 1: 228. 1838.
Illiamna acerifolia Greene, Leaflets 1: 206. 1906.

Phymosia rivularis (Dougl.) Rydb.

Malva rivularis Dougl.; Hook. Fl. Bor.-Am. 1: 107. 1831.
Sphaeralcea rivularis Torr. in Gray, Mem. Am. Acad. 4: 23. 1849.
Illiamna rivularis Greene, Leaflets 1: 206. 1906.

Phymosia grandiflora Rydb.

Sphaeralcea grandiflora Rydb. Bull. Torrey Club 31: 565. 1904.
Illiamna angulata Greene, Leaflets 1: 206. 1906.

Phymosia Crandallii Rydb.

Sphaeralcea Crandallii Rydb. Bull. Torrey Club 31: 564. 1904.

* Leaflets 1: 205–207. 1906.

Phymosia longisepala (Torr.) Rydb.

Sphaeralcea longisepala Torr. Bot. Wilkes Exped. 255. 1874.

LOASACEAE

Nuttallia* humilis (A. Gray) Rydb.

Mentzelia multiflora humilis A. Gray, Pl. Wright 1: 74. 1852.

Touterea humilis Rydb. Bull. Torrey Club 30: 277. 1903.

Nuttallia integra (M. E. Jones) Rydb.

Mentzelia multiflora integra M. E. Jones, Proc. Calif. Acad. II. 5: 689. 1895.

Touterea integra Rydb. Fl. Colo. 235. 1906.

Nuttallia Rusbyi (Wooton) Rydb.

Mentzelia Rusbyi Wooton, Bull. Torrey Club 25: 261. 1898.

Touterea Rusbyi Rydb. Bull. Torrey Club 30: 276. 1903.

Nuttallia lobata Rydb. sp. nov.

Perennial with a thick root; stems strict, glabrous or nearly so, white and shining, 3–4 dm. high; leaves 5–8 cm. long, 5–8 mm. wide, narrowly oblanceolate, sinuately toothed or lobed with short triangular lobes; sepals lanceolate, acuminate, 8–10 mm. long; flowers diurnal, subtended by narrowly linear bracts; petals golden yellow, spatulate, obtuse, 12–18 mm. long; petaloid staminodia similar and almost as large; filaments numerous, the outer dilated; capsule 15 mm. long, 8–9 mm. thick, acute, almost turbinate at the base; seeds suborbicular, broadly winged.

This species is related to *N. multiflora* (Nutt.) Greene and *N. pterosperma* (Eastwood) Greene. It differs from the former in the narrow merely toothed or lobed not pinnatifid leaves; from the latter in the acute teeth or lobes of the leaves and the capsule, which is acute not rounded at the base, and from both in the glabrous stem.

UTAH: Near St. George, 1877, *Palmer 172* (type, in herb. Columbia Univ.); 1874, *Parry 76;* 1902, *Goodding 776.*

Nuttallia acuminata Rydb. sp. nov.

Stout biennial; stem 3–10 dm. high, straw-color, white in age, rather dull, densely villous with barbed hairs; lower leaves

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* "*Nuttallæ*" Rafin. Am. Mo. Mag. (1818): 175. 1818; "*Nuttallia*", Greene. Leaflets 1: 209. 10 Ap. 1906.

oblanceolate, 1–2 dm. long, sinuately dentate, densely scabrous with triangular teeth; upper stem-leaves lanceolate, long-acuminate, pinnatifid with lanceolate or rarely triangular lobes, the lower ones of which are usually large and salient, the base of the leaves, therefore, being very broad and truncate; flowers diurnal; their bracts narrowly linear, entire or with a few narrow lobes; sepals 2–3 cm. long, lance-subulate, long-acuminate, light yellow, about 5 cm. long; outer filaments slightly dilated, the rest filiform, three fourths as long as the petals; petaloid staminodia none; capsule 4 cm. long, 1 cm. thick; seeds obovate, winged.

This species has been confused with *N. laevicaulis* (Hook.) Greene, but differs in the pubescent, duller stem (in *N. laevicaulis* this is glabrous or with a few scattered stiff hairs, very white and shining), broader petals, more deeply divided upper stem-leaves, which are characterized by their acumination and broad almost subhastate bases. *N. acuminata* extends farther eastward and northward than *N. laevicaulis* and is lacking in California.

IDAHO: Spokane River, Kootenai County, 1892, *Sandberg, MacDougal & Heller 651* (type, in herb. N. Y. Bot. Gard.); Palouse County and Lake Coeur d'Alene, *Aiton 6015*.

MONTANA: Emigrant Gulch, 1897, *Rydberg & Bessey 4546;* Sedan, 1902, *W. W. Jones;* Garrison, 1895, *Rydberg 2737*, and *C. L. Shear 5248;* Helena, 1892, *Kelsey*.

WYOMING: Between Sheridan and Buffalo, 1900, *Tweedy 3617;* Gardiner River, 1899, *Aven Nelson & Elias Nelson 6000*.

UTAH: City Creek, 1883, *Leonard 116 and 227;* Beck's Hot Spring, 1905, *Garrett 1595;* Antelope Island and Stansbury Island, *Stansbury*.

WASHINGTON: Loon Lake, 1897, *Winston;* Spokane, 1902, *Kraeger 529*.

ONAGRACEAE

Boisduvalia salicina (Nutt.) Rydb.

Oenothera densiflora β T. & G. Fl. N. Am. 1: 505. 1840.
Oenothera salicina Nutt. in T. & G. *loc. cit.*, as a synonym.

This is quite different in habit from the typical *B. densiflora* (Lindl.) S. Wats., having the foliage-leaves narrow, linear or linear-lanceolate. It has a much more northern and eastern range, extending into British Columbia and Idaho.

Epilobium latiusculum Rydb. sp. nov.

Epilobium Drummondii latiusculum Rydb. Mem. N. Y. Bot. Gard. 1: 276. 1900.

To the characters given in the original description may be added that the leaves are distinctly petioled, not sessile as in *E. Drummondii.*

Epilobium platyphyllum Rydb. sp. nov.

Epilobium glaberrimum latifolium Barbey, Bot. Calif. 1: 220. 1876. Not *E. latifolium* L. 1753.

Epilobium paniculatum, as usually understood, contains several forms or species, connecting on one hand with *E. minutum*, on the other with *E. jucundum.* In order to facilitate the further study of the groups, I give the following key of the Rocky Mountain forms.

Tube of the hypanthium funnelform, 1–3 mm. (rarely 4 mm.) long.
  Petals white only slightly exceeding the calyx, 2–3 mm. long; capsule glabrous; tube of hypanthium 1–1.5 mm. long. 1. *E. Tracyi.*
  Petals pink or purple, 3.5–7 mm. long, about twice as long as the calyx.
    Capsule and pedicels glabrous or sparingly puberulent.
      Leaves and bracts very thick, horny at the apex, the latter very short; capsule glabrous; pedicels short. 2. *E. subulatum.*
      Leaves and bracts not very thick, not horny at the apex; capsule usually puberulent. at least when young; pedicels slender. 3. *E. paniculatum.*
    Capsule and pedicels glandular-pubescent; pedicels very short. 4. *E. adenocladum.*
Tube of the hypanthium 4–8 mm. long, cylindric or nearly so, abruptly widening into the calyx.
  Tube of the hypanthium about 4 mm. long; petals 6-7 mm. long. 5. *E. laevicaule.*
  Tube of the hypanthium 7–8 mm. long; petals 10–12 mm. long. 6. *E. Hammondii.*

Epilobium Tracyi Rydb. sp. nov.

Annual; stem 3–8 dm. high, perfectly glabrous, straw-colored; leaves 2–4 cm. long, linear, entire, glabrous; tube of the hypanthium 1–1.5 mm. long, funnelform; calyx-lobes about 2 mm. long, very acute; petals white, 2–3 mm. long; capsule more or less

clavate, about 1.5 cm. long, perfectly glabrous; seeds obovoid, 1.5 mm. long.

This species is related to *E. paniculatum* but differs in the small white flowers and the perfectly glabrous pod.

UTAH: Ogden, July 31, 1887, *Tracy & Evans 547* (type, in herb. N. Y. Bot. Gard.); Salt Lake City, May 1869, *Watson 396.*

OREGON: Washington County, July 4, 1894, *F. E. Lloyd.*

WASHINGTON: Spokane, July 11, 1902, *Kraeger 152.*

IDAHO: Little Potlatch River, Latah County, June 17, 1892, *Sandberg, MacDougal & Heller 477.*

MONTANA: Moraine near Polson, August 18, 1901, *Umbach.*

BRITISH COLUMBIA: Howser Lake, Selkirk Mts., June 17, 1905, *Charles H. Shaw 714.*

NEVADA: Huntington Valley, August 1868, *Watson 396.*

Epilobium subulatum (Haussk.) Rydb.

Epilobium paniculatum subulata Haussk. Monog. Epil. 247. 1884.

Epilobium laevicaule Rydb. sp. nov.

Annual; stem glabrous, 6–10 dm. high, glabrous and shining; the bark of the lower portion flaky; leaves linear or linear-lanceolate, 3–6 cm. long; the upper mostly involute, usually entire; tube of the hypanthium about 4 mm. long, rather abruptly widening into the calyx; calyx-lobes 3–4 mm. long; petals rose-colored, 6–7 mm. long; pods clavate, about 3 cm. long, glabrous or almost so; seeds obovoid, dark; coma dingy.

MONTANA: Manhattan, 1895, *Rydberg 2728* (type, in herb. N. Y. Bot. Gard.); *Shear 3114;* Big Fork, Aug. 3, 1909, *Butler 7016.*

WASHINGTON: Pullman, Aug. 5, 1893, *Piper 1631;* Spokane, Sept. 1902, *Kraeger 536* and *573.*

IDAHO: Palouse County, 1892, *G. B. Aiton 69;* Seven Devils Mountains, Aug. 5, 1899, *M. E. Jones 6317.*

Epilobium Sandbergii Rydb. sp. nov.

Perennial by means of turions; stem obtusely angled, 6–10 dm. high, finely puberulent throughout; leaves sessile, ovate, acute, dentate, 3–7 cm. long, pubescent on both sides, or glabrate beneath, except the veins; inflorescence crisp-hairy; calyx-lobes linear-lanceolate, about 5 mm. long; petals rose, 7–8 mm. long; pod 4–6 cm. long, glandular-pilose; seeds 1.5 mm. long, almost beakless; coma tawny.

It resembles somewhat *E. Palmeri*, but the flowers are nearly twice as large.

IDAHO: Moist places, valley of Mud Lake, Kootenai County, July 25, 1892, *Sandberg, MacDougal & Heller 737* (type, in herb. N. Y. Bot. Gard.).

MONTANA: Bozeman, July 22, 1895, *Rydberg 2729*.

Gayophytum Helleri Rydb. sp. nov.

Annual; stem branched with nearly erect, strict branches, 1–3 dm. high, more or less pubescent with spreading hairs; leaves linear, 0.5–2 cm. long, softly hirsutulous; pedicels very short, even in fruit scarcely more than 1 mm. long; sepals and petals scarcely 1 mm. long; capsules linear, erect, 8–10 mm. long, almost sessile, hirsutulous, not torulose; seeds about 1 mm. long, strigulose.

This resembles *G. racemosum* in habit and the pod, *G. caesiun* in pubescence and *G. lasiospermum* in the seeds.

IDAHO: Forest, Nez Perces County, July 16, 1896, *Heller 3433* (type, in herb. N. Y. Bot. Gard.).

Anogra leptophylla (Nutt.) Rydb.

Oenothera pallida leptophylla (Nutt.) T. & G. Fl. N. Am. 1: 495. 1840.

Oenothera leptophylla Nutt.; T. & G. Fl. *loc. cit.*, as a synonym.

Oenothera longissima Rydb. sp. nov.

A tall biennial; stem strict, 5–10 dm. high, densely canescent with short crinkled hairs as well as sparingly hirsute; leaves linear or narrowly linear-lanceolate, 1–1.5 dm. long, densely canescent, entire, acute at both ends, the lower short-petioled; spike rather lax; bracts linear-lanceolate, 2–5 cm. long; hypanthium tube 10–12 cm. long, densely canescent, only slightly widening upwards; sepals linear-lanceolate, about 4 cm. long; free tips about 4 mm. long; petals golden yellow, 4 cm. long; stamens and pistil of about the same length; capsule about 4 cm. long, densely canescent, slightly tapering upwards.

This is related to *O. macrosceles* A. Gray and *O. Jamesii* T. & G., but differs from the former in being canescent instead of glabrous and in the smaller and narrower bracts, and from the latter in the longer, narrower and entire-margined leaves, and in being more canescent and less hirsute. It grows on sandy river banks at an altitude of about 1,600 m.

UTAH: Armstrong and White Canyons near the Natural Bridges, Aug. 4–6, 1911, *Rybderg & Garrett 9410* (type, in herb. N. Y. Bot. Gard.).

Oenothera ornata (A. Nelson) Rydb.

Onagra ornata A. Nels. Bot. Gaz. **52**: 268. 1911.

Oenothera hirsutissima (A. Gray) Rydb.

Oenothera biennis hirsutissima A. Gray, Mem. Am. Acad. **4**. 43. 1849.

This usually has been regarded as the same as *O. Hookeri* T. & G. The type of the latter came from California, that of the former from New Mexico. In the plant common in California and the Great Basin, the free tips of the sepals are about 4 mm. long, the pubescence of the leaves is short and that of the calyx not very copious. In the type of *O. biennis hirsutissima* and other specimens from New Mexico and Colorado, the free tips of the sepals are only 2–2.5 mm. long, the pubescence of the leaves and calyx long and loose, and that of the latter very copious.

Oenothera subulifera (Rydb.)

Onagra strigosa subulata Rydb. Mem. N. Y. Bot. Gard. **1**: 279. 1900. Not *O. subulata* R. & P. 1802

Onagra Oakesiana Rydb. Fl. Colo. 244. 1906. Not *Oenothera Oakesiana* A. Gray. 1867.

Chylisma tenuissima (M. E. Jones) Rydb.

Oenothera tenuissima M. E. Jones, Proc. Calif. Acad. II. **5**: 683. 1895.

Sphaerostigma macrophyllum (Small) Rydb.

Oenothera alyssoides villosa S. Wats. Proc. Am. Acad. **8**: 591. 1873. Not *O. villosa* Thunb. 1794–1800.

Sphaerostigma alyssoides macrophyllum Small, Bull. Torrey Club **23**: 192. 1896.

AMMIACEAE

Osmorrhiza intermedia Rydb.

Washingtonia intermedia Rydb. Mem. N. Y. Bot. Gard. **1**: 289. 1900.

Glycosma maxima Rydb. sp. nov.

Perennial; stem 1 m. high or more, puberulent or glabrous, pilose at the nodes; lower leaves twice compound, first pinnate and the lower primary divisions ternate; the upper leaves ternate or twice ternate; leaflets oblong-lanceolate, 5–10 cm. long, minutely puberulent; branches of the umbels 9–12, in fruit more or less spreading; pedicels in fruit 1–1.5 cm. long; fruit fully 2 cm. long, obtuse at the base, contracted above into a beak 2 mm. long; stylopodium conical, 0.5 mm. long, about as long as the styles.

This is related to *G. occidentalis* Nutt., but the fruit is much larger (in *G. occidentalis* only 12–16 mm., rarely 18 mm. long), and the rays of the umbels are in fruit usually widely spreading, while in *G. occidentalis* they are nearly erect. The spreading rays suggest *G. ambigua* and *G. Bolanderi*, but in both these species the stylopodium is flatter.

UTAH: Mount Nebo, Aug. 15, 1905, *Rydberg & Carlton 7585* (type, in herb. N. Y. Bot. Gard.); Rocky Canyon, Provo, Aug. 16, 1887, *Tracy 684.*

MONTANA: Midvale, July 24, 1903, *Umbach 508.*

ATENIA H. & A. Bot. Beech. Voy. 349. 1840

This I think is a good genus, distinct from *Carum.* Although the fruit is almost the same, the habit is quite different. The habit of *Atenia* is the same as that of *Eulophus.* In fact it is hard to distinguish the two genera without mature fruit, both having the fascicled tuberous roots, the narrow leaf-segments, the same inflorescence and flowers. The only essential differences are the deeply concave seed-face with a central ridge and the several oil tubes in *Eulophus* and the plane face and solitary oil tubes in *Ataenia.* The following species are found in the Rocky Mountains:

ATENIA GAIRDNERI H. & A. Bot. Beech. Voy. 349. 1840

Edosmia Gairdneri Nutt.; T. & G. Fl. N. Am. 1: 612. 1840.
Carum Gairdneri A. Gray, Proc. Am. Acad. 7: 344. 1867.

Atenia montana (Blank.) Rydb.

Carum montanum Blank. Mont. Agr. Coll. Sci. Bot. 1: 91. 1905.

Atenia Garrettii (A. Nels.) Rydb.

Carum Garrettii A. Nels. in Rose, Cont. U. S. Nat. Herb. **12**: 443. 1909.

Oreoxis MacDougali (C. & R.) Rydb.

Aletes MacDougali C. & R. Cont. U. S. Nat. Herb. **7**: 107. 1900.

This was doubtfully referred to *Aletes* by Coulter and Rose. The fruits in the type collection were very young and did not show their true nature. Anyhow, they showed distinct wings, a character inconsistent with the genus *Aletes*. Professor Garrett and myself collected good fruits in southeastern Utah in the summer of 1911; and these show that the plant is rather an *Oreoxis* than an *Aletes*, wings being present and these thick and corky. The two genera are, however, more closely related than has been recognized, having the same cespitose habit, the prominent calyx, teeth, etc.

Daucophyllum (Nutt.) Rydb. gen. nov.

Musenium § *Daucophyllum* Nutt.; T. & G. Fl. N. Am. **1**: 642. 1840.

Low cespitose perennials, acaulescent or nearly so, with a branched caudex. Leaves numerous, basal, or 1 or 2 cauline, pinnate or bipinnate with filiform or narrowly linear divisions. Flowers cream-colored to yellow, in dense umbels. Bracts wanting; bractlets few, narrow, linear. Calyx teeth prominent. Stylopodium wanting. Fruit ovoid or oblong, granular on the intervals. Ribs equal, rather strong, but not at all winged. Oil tubes 2 or 3 in the intervals, 4–6 on the commissural side. Seed terete or somewhat depressed; face plane.

The type, *Musenium tenuifolium* Nutt., was separated as a section in Torrey and Gray's Flora. The relationship is rather with *Harbouria* and *Aletes* than with *Musineon* Raf. The first-mentioned relationship was recognized by Coulter and Rose (see their Revision, p. 111). It differs from *Harbouria* in not having thick corky ribs and in having several oil tubes in the intervals. It is still more closely related to *Aletes*, having the same habit, although narrower leaf-segments, the main differences being, however, the solitary oil tubes in *Aletes* and 2 or 3 in each interval in *Daucophyllum*, and the concave seed face in the former and the plane

one in the latter. The second species given below was included questionably in *Aletes* by Coulter and Rose; but in the number of oil tubes and the plane seed face it agrees better with *Musenium tenuifolium* Nutt. than with the typical species of *Aletes*.

Leaves bipinnate; segments filiform; bractlets not exceeding the pedicels; seed subterete. 1. *D. tenuifolium.*

Leaves pinnate; segments narrowly linear; bractlets longer than the pedicels; seeds somewhat depressed. 2. *D. lineare.*

1. **Daucophyllum tenuifolium** (Nutt.) Rydb.

Musenium tenuifolium Nutt.; T. & G. Fl. N. Am. 1: 642. 1840.

2. **Daucophyllum lineare** Rydb. nom. nov.

Aletes tenuifolia C. & R. Cont. U. S. Nat. Herb. 7: 108. 1900.

Coriophyllus (M. E. Jones) Rydb. gen. nov.

Cymopterus §*Coriophyllus* M. E. Jones, Cont. West. Bot. 12: 20. 1908.

Perennial herbs with more or less fleshy root, somewhat branched rootstock covered with fibrous sheaths, and leafy stems with internodes shorter than the leaf-sheaths. Flowers yellow to purple. Bracts none; bractlets present, but narrow. Leaves pinnately dissected, subcoriaceous, rigid, not fleshy, with ovate or lanceolate, cuspidate or spinulose-tipped lobes. Calyx teeth evident. Stylopodium wanting. Fruit orbicular to oval in outline, usually emarginate at both ends, compressed laterally if at all. Ribs with broad wings. Oil tubes 1–5 in the intervals, 2–8 on the commissural side. Seeds little if at all flattened dorsally; face deeply grooved.

I agree with Mr. Marcus E. Jones that the genus *Aulospermum*, as constituted by Coulter and Rose, is a rather unnatural one, made up of two groups of quite different habit; but instead of reducing both groups to sections of *Cymopterus* as Mr. Jones did, I rather regard them as two distinct genera, and adopt for the second group the sectional name first proposed by Mr. Jones. (See the discussion in Cont. West. Bot. 12: 19–20 and 27.) He, however, had the group under two different sectional names. The section is called *Coriophyllus* on page 20 and *Scopulicola* on page 27.

The following species are found in the Rockies and are distinguished thus:

Wings thickened at the insertion.
- Leaves ternately bipinnatifid; oil tubes solitary in each interval. 1. *C. Jonesii.*
- Leaves pinnate, with lobed or divided leaflets; oil tubes several in each interval. 2. *C. Rosei.*

Wings not thickened at the insertion.
- Flowers purplish; oil tubes 8 on the commissural side. 3. *C. purpureus.*
- Flowers greenish-yellow; oil tubes 4 on the commissural side. 4. *C. Betheli.*

1. **Coriophyllus Jonesii** (C. & R.) Rydb.

Cymopterus Jonesii C. & R. Rev. N. Am. Umb. 80. 1888.
Aulospermum Jonesii C. & R. Cont. U. S. Nat. Herb. 7: 178. 1900.

2. **Coriophyllus Rosei** (M. E. Jones) Rydb.

Aulospermum Rosei M. E. Jones; C. & R. Cont. U. S. Nat. Herb. 7: 179. 1900.

3. **Coriophyllus purpureus** (S. Wats.)

Cymopterus purpureus S. Wats. Am. Nat. 7: 300. 1872.
Aulospermum purpureum C. & R. Cont. U. S. Nat. Herb. 7: 178. 1900.

4. **Coriophyllus Betheli** (Osterhout) Rydb.

Aulospermum Betheli Osterhout, Muhlenbergia 6: 46. 1910.

PSEUDOCYMOPTERUS C. & R.

This genus is one of the most unnatural in Coulter & Rose's Monograph. Jones* called attention to this fact, although he included the genus, as well as *Oreoxys*, *Rhysopterus*, *Aulospermum*, and *Pteryxia* in *Cymopterus*, and does not go to the bottom of the facts. The genus as constituted by Coulter and Rose contains at least three distinct groups of plants of little relationship to each other. The first group contains *Pseudocymopterus montanus* and its close relatives; the second of *P. anisatus* and *P. aletifolius*, and perhaps *P. Hendersonii*, which I do not know; and the third of *P. bipinnatus* and probably *Cymopterus nivalis* S. Wats., of which the fruit is unknown. *P. montanus* is the type of the genus, which latter therefore must be restricted to it and its relatives. Jones

* Cont. West. Bot. 12: 24–29. 1908.

includes *P. anisatus* and *P. bipinnatus* in his section *Oreoxis*, but the genus *Oreoxis* has all ribs corky and the lateral ones scarcely more prominent than the dorsal ones, the fruit is not flattened dorsally, the styles and sepals are erect. In *Pseudocymopterus anisatus* the lateral wings are very prominent, the dorsal ribs narrowly winged or some of them merely acute, the styles are recurved, the sepals spreading and one or two of them larger than the rest, and the fruit is decidedly flattened dorsally. The plant is more related to *Aletes* than to *Oreoxis*, and *P. aletifolius* connects it with that genus. It can not be placed in *Aletes*, however, for in that genus the fruit is not compressed and the ribs not winged. It would be much better to include *P. anisatus* and *P. aletifolius* in *Pteryxia*, as they have the foliage and nearly the same fruit as in that genus, but the strictly acaulescent plant, the narrow and thick wings of the fruit and the very prominent and unequal calyx-teeth would make it rather abnormal even in that genus. Although it does not differ so much in the technical characters of the fruit from the typical *Pseudocymopterus*, the habit is quite different, so also the texture of the leaves, and in *Pseudocymopterus* the sepals are minute. It is better to regard *P. anisatus* as a type of a new genus.

Pseudopteryxia Rydb. gen. nov.

Densely cespitose, strong-scented, acaulescent perennials with multicipital caudices covered with numerous sheaths of old leaves. Leaves pinnatifid or bipinnatifid with thick, firm, pungent divisions. Flowers yellow; involucres wanting; bractlets linear-subulate, pungent. Calyx-teeth very prominent, spreading, unequal, one or two much longer than the rest. Stylopodium wanting. Fruit oblong, glabrous. Ribs thick, the dorsal and intermediate ones sharp or some of them with narrow wings; the lateral ones with broader wings, distinct from those of the other carpel. Carpels flattened dorsally. Oil tubes 1–3 in the intervals, 2–4 on the commissural side. Seed face plane.

Pseudopteryxia anisata (A. Gray) Rydb.

Cymopterus (?) *anisatus* A. Gray, Proc. Acad. Phila. 1862: 63. 1863.

Pseudocymopterus anisatus C. & R. Rev. N. Am. Umb. 75. 1888.

Pseudopteryxia longiloba Rydb. sp. nov.

Densely cespitose perennial with a thick root and short caudex, covered by numerous old leaf-sheaths and petioles; leaves twice pinnatifid, with linear-subulate, pungent divisions; peduncles 2–3 dm. high, stout; bractlets linear-subulate, spreading, often 1 cm. long; flowers yellow; fruit about 6 mm. long; lateral wings thick, narrow, some of the wings of the dorsal ribs often fully as broad; calyx-teeth less prominent than in *P. anisata.*

This is closely related to *P. anisata*, differing in the larger fruit (in *P. anisata* about 4 mm. long), and longer leaf-segments. On account of the long leaf-segments, specimens collected in flower by Carlton and myself were mistaken for *Cynomarathrum Nuttallii* (A. Gray) C. & R.; but good fruit was received in the summer of 1911.

UTAH: Abajo Mountains, Aug. 17, 1911, *Rydberg & Garrett 9761* (fruit; type, in herb. N. Y. Bot. Gard.); also *9760* (fruit); La Sal Mountains, July 7 and 17, *8724* and *9015* (young fruit); Mountains north of Bullion Creek, near Marysvale, July 23, *Rydberg & Carlton 7085* and *7096* (flowers); Mount Ellen, July 24 and 25, 1894, *M. E. Jones 5677* (fruit, but poor).

Pseudopteryxia aletifolia Rydb.

Pseudocymopterus aletifolius Rydb. Bull. Torrey Club **31**: 574. 1904.

Neither can *Pseudocymopterus bipinnatus* be retained in the genus; in fact, it is still more out of place. Not only is the habit strikingly different from that of *P. montanus*, but the fruit is not, as Coulter and Rose described it, "moderately flattened dorsally," for the fruit when well developed is moderately flattened laterally, which places it in the other division of the family. Furthermore, the seed face is concave, the bractlets broad and scarious, and a stylopodium, although strongly flattened, is present. Were it not for these characters of the fruit the plant could be placed in the same genus as *P. anisatus.* As it is, its relationship is with *Daucophyllum* and *Aletes.* I would place it in *Daucophyllum* were it not for the winged ribs, the concave seed face and the reflexed style. The fruit is nearer that of *Aletes*, but the oil tubes are several, the ribs winged, styles reflexed and stylopodium present. If a person were using the key given by Coulter and Rose

in their Monograph and were trying to determine the plant, the key would lead to *Aulospermum* or *Phellopterus*, to either of which genera it is not even closely related. Mr. Jones included it in *Oreoxis*, to which I admit it is related, but the ribs are not corky, the stylopodium present, the styles reflexed, the flowers white, not yellow, and the bractlets scarious.

Pseudoreoxis Rydb. gen. nov.

Low cespitose acaulescent perennials, with branched caudex. Leaves bipinnate; the segments more or less cleft with small lanceolate divisions. Flowers white in small umbels; bracts wanting; bractlets ovate or lanceolate, cuspidate or abruptly acuminate, scarious, white with a green midrib. Calyx-teeth evident but small. Stylopodium present but low and flat. Styles reflexed. Fruit somewhat flattened laterally, oblong. Ribs all with narrow wings, the lateral ones scarcely wider. Oil tubes 3 or 4 in the intervals, 6–8 on the commissure. Seed face slightly concave.

Pseudoreoxis bipinnatus (S. Wats.) Rydb.

Cymopterus bipinnatus S. Wats. Proc. Am. Acad. **20**: 368. 1885.
Pseudocymopterus bipinnatus C. & R. Rev. N. Am. Umbel. 75. 1888.

Pseudoreoxis nivalis (S. Wats.) Rydb.

Cymopterus nivalis S. Wats. Bot. King. Exped. 123. 1871.

I do not hesitate to refer this species to the same genus as *P. bipinnatus*, although the fruit is unknown, for the habit, and flowers are so closely resembling those of *P. bipinnatus*.

Cynomarathrum latilobum Rydb. sp. nov.

Acaulescent perennial with densely cespitose caudex covered by old broad leaf-sheaths; leaves about 1 cm. long, pinnate, glabrous; leaflets entire or 2- or 3-cleft into broadly lanceolate, reticulate, thick, pointed segments 5–15 mm. long; peduncles 1–1.5 dm. long, stout; rays 1–2 cm. long; bractlets linear or lance-linear, 5–6 mm. long; flowers apparently straw-colored or ochroleucous; fruit about 9 mm. long, 6 mm. wide; lateral wings about as broad as the body; dorsal ribs filiform or some of them narrowly winged; oil tubes 2–4 in the intervals, 4–6 on the commissure, rather obscure.

The fruit of this species is intermediate between that of *C. Nuttallii* and *C. Parryi*, but the plant differs from both, as well as from all the known species, in the broad segments of the leaves.

The segments resemble those of some species of *Cogswellia* of the *C. triternata* group, but the leaves are pinnate, not ternate, the plant has the densely cespitose, sheath-covered caudex characteristic of *Cynomarathrum*, and the fruit is of that genus, having some of the dorsal ribs winged, and the calyx-teeth are prominent. It grows on sides of canyons at an altitude of 1,600 m.

UTAH: Proposed dam site, near Wilson Mesa, Grand County, Utah, July 1, 1911, *Rydberg & Garrett 8371* (fruit; type, in herb. N. Y. Bot. Gard.); also *8414* (withered flowers).

Cogswellia simplex (Nutt.) Rydb.

Peucedanum triternatum platycarpum Torr. Stansb. Rep. 389. 1852.
Peucedanum simplex Nutt.; S. Wats. Bot. King. Exped. 129. 1871.
Lomatium platycarpum C. & R. Cont. U. S. Nat. Herb. 7: 226. 1900.
Cogswellia platycarpa (Torr.) M. E. Jones, Cont. West. Bot. 12: 32. 1908.

It was unfortunate that an amendment to the Rochester Code ever was passed at Madison, by which a varietal name could supersede a specific name, and I am glad that the amendment mentioned has been recalled and that we can return to the specific name well known by a long usage.

Cogswellia leptophylla (Hook.) Rydb. sp. nov.

Peucedanum triternatum leptophyllum Hook. Lond. Journ. Bot. **6**: 235. 1847.

This species is related to *C. simplex*, *C. triternata*, and *C. robustior*. In general habit, it resembles most the second, but the leaflets are narrower, the fruit is shorter and relatively broader and puberulent. *C. simplex* has less compound leaves, broader leaflets, larger and glabrous fruit; *C. robustior* has much broader and more spreading leaflets, longer fruit with very narrow wing.

MONTANA: Helena, June–July, 1891, *Kelsey;* also May, 1890; University campus and hillsides, Missoula, 1901, *MacDougal 130;* Old Sentinel, June 12, 1901, *MacDougal;* Deer Lodge, June, 1888, *Traphagen;* Mt. Ascension, Helena, 1909, *Butler 4057*.

IDAHO: Hills near Boise, June 7, 1892, *Isabel Mulford;* Weiser, April 18, 1900, *M. E. Jones 6336*.

NEW YORK BOTANICAL GARDEN.

Tetradesmus, a new four-celled coenobic alga

GILBERT MORGAN SMITH

(WITH PLATE I)

METHODS AND MATERIAL

The alga described below was obtained during a study of various algae in pure cultures. The isolation of the different algae was by means of a medium consisting of 0.2% Knop's (9) solution and 2.0% agar in Petri dish cultures. By this method cultures were obtained which were the descendants of a single cell. Great care was used in the isolation, and only those cultures that were entirely free from other algae and bacteria were used in this study. After the isolation, cultures were made in sterile Knop's solution in 200 c.c. Erlenmeyer flasks. A complete description of the methods used will be given in a forthcoming paper.

The details of the cellular structure were studied in material which had been fixed in Flemming's weak osmic-acetic-chromic acid mixture diluted with an equal volume of water. For the washing and dehydration of the material a modification of Osterhout's (12) method was used. After the material had been allowed to stand in the killing solution for 24 hours, as much as possible of the solution was removed from the vial by means of a pipette, and then the vial was filled with distilled water. A celloidin film was prepared by pouring a celloidin solution on a clean surface of mercury and allowing it to harden so that it could be lifted up and placed over the mouth of the vial. The membrane was then allowed to harden still further while on the mouth of the vial. The material was then washed by simply placing it in a dish containing running water. For the purpose of dehydration the vial was transferred to 70 per cent. alcohol for 12 hours and then to two successive portions of 95 per cent. alcohol, at intervals of 12 hours. By means of this method the loss of material through decantation was obviated. The material was imbedded in paraffin and cut on a microtome into sections of from 3 to 5 μ in thickness.

The triple stain of Flemming gave the best differentiation, and all drawings are from preparations made in this manner.

I wish to express my thanks here to Professor Charles E. Allen for kind criticism and keen interest shown during the progress of this work and preparation of the manuscript.

DIAGNOSIS

The alga in question normally occurs in the form of four-celled colonies. The characteristic feature of the arrangement of the cells is that when viewed from the side they are seen to be in two tiers, while in *Scenedesmus*, apparently the most nearly related form, the cells are all in a single plane. The shape of the cells varies somewhat with their age, the mature ones being more ovoid. The following are the descriptions of the genus and species:

Tetradesmus gen. nov.

Colonies free, of 4 cells, rarely 1 or 2; cells in two planes, 2 cells in each plane, joined along the longer axes, ovoid with pointed ends; chlorophyl present throughout the cell, pyrenoid single. Reproduction by autocolonies inside of old cell wall, liberated by rupture of mother cell wall.

Coenobia segregata, e cellulis quaternis (rarius 1–2). Cellulae binae latere longiore in seriem duplicem conjunctae, ovoideae utroque polo acutae, homogeneae chlorophyllosae, et pyrenoide singulo praeditae. Propagatio fit autocoenobiis intra cellulam matricalem quae membranae ruptura prodeunt.

Tetradesmus wisconsinensis sp. nov.

Cells ovoid with sharply pointed ends, 4–5.8 by 12–14.5 μ.

HABITAT: Floating in sluggish streams and lakes; Madison, Wisconsin.

Cellulae ovoideae utroque polo acutae, 4–5.8 $\mu \times$ 12–14.5 μ.

HABITAT: In rivulis lente fluentibus et lacubus libere natantes. Madison, Wisconsin.

The characters described above are sufficient, in my opinion, to warrant the assumption that we have a new genus. The objection may be made that this is merely a cultural form of *Scenedesmus acutus* Meyen; for according to Chodat (3), Chodat

and Malinesco (4) (5), and Grintzesco (6), *Scenedesmus acutus* shows great variation under different cultural conditions. The regular arrangement of the cells in a linear series may disappear and the cells become isolated or arranged in the branching chain-like colonies which Naegeli (11) has described under the name of *Dactylococcus*. Although not at all conclusive, the fact is worthy of mention here that these investigators found no variation of *Scenedesmus acutus* which looked at all like *Tetradesmus*.

The alga in question has been under constant observation for over nine months and cultivated in different media, such as Knop's solution in different concentrations, Knop's solution with glucose or cane sugar, Beyerinck's (2) solution, and Knop's solution with 0.2–2% sodium chlorid. It has been cultivated under different conditions of illumination and temperature, and under none of these conditions has a colony been found with the cellular arrangement characteristic of *Scenedesmus acutus*. Conversely the evidence is just as strong, for I have had several different strains of *Scenedesmus acutus* under observation for the same length of time and under the same differing conditions, and in these cultures forms resembling *Tetradesmus* have never been found. If *Tetradesmus* were a cultural form of *Scenedesmus acutus*, the change from one form to the other should have been observed in this extensive series of cultures.

In the size, shape, and structure of the individual cells the two species also show constant differences. The cells of *Tetradesmus wisconsinensis* vary in size from 4–5.8 μ in width when the alga is grown in 0.1% Knop's solution; those of *Scenedesmus acutus* under the same conditions are 6.2–4.5μ in width. When the alga is grown in a 1.0% Knop's solution, the average diameter of the *Scenedesmus* cell increases to 6–7.8 μ, that of the *Tetradesmus* cell remaining practically unchanged. With the change to the stronger solution there is no change in the length of the individual cells. This change from the acicular to the ovoid-round shape of the cell in *Scenedesmus acutus*, when the concentration of the medium is increased, has been already pointed out by Senn (14). On the other hand, *Tetradesmus* shows no appreciable change in the shape of the cells when the concentration of the nutritive solution is increased. Beyerinck (1) and Senn (14) have shown that

in weaker nutritive solutions the chromatophore of *Scenedesmus acutus* does not fill the entire cell but that there is a hyaline region at one side. My experiments with *Scenedesmus acutus* confirm this point; however, the chromatophore in *Tetradesmus* always completely fills the cell. The pyrenoid of *Scenedesmus* is constantly somewhat larger than that of *Tetradesmus*, being about 2.5 μ in diameter in the former and 1.5 μ in the latter. The arrangement of the starch grains differs somewhat, the characteristic segmentation of the grains around the pyrenoid being easily seen in *Scenedesmus* and only with great difficulty in *Tetradesmus*. In the older cultures of the former species the cell is usually filled with characteristic angular pieces of "stroma" starch that have been derived from the pyrenoid; in *Tetradesmus* kept under similar conditions the "stroma" starch granules are not very abundant. A good idea of the cellular structure of *Scenedesmus acutus* may be obtained from FIG. 3.

Among other coenobic algae the forms which appear to resemble *Tetradesmus* most closely are *Selenastrum* Reinsch (17) and *Lauterborniella* Schmidle (13). *Selenastrum*, as described by West (17), differs from *Tetradesmus* in that there are more than four cells in some of the colonies, and that the individual cells do not possess a pyrenoid. Dr. Schmidle has kindly compared my material with his type specimens of *Lauterborniella* and informs me that neither in size, shape, nor arrangement of the cells does *Tetradesmus* resemble *Lauterborniella*.

MORPHOLOGY

The individual cells of the *Tetradesmus* colony are always more or less ovoid, but in every case they are sharp-pointed at the ends. The cell wall is composed of two parts, as Chodat and Malinesco (4) have shown for *Scenedesmus*. The inner part is of cellulose and reacts to zinc chloriodid; the outer is composed of a gelatinous material which serves to bind the cells of the colony together. The existence of this outer gelatinous layer can be demonstrated by the use of some such stain as Bismarck brown. There is no central vacuole, but the entire cell except for the nucleus and the pyrenoid is filled with a cytoplasm which is granular or rarely slightly alveolar in structure. The chlorophyl is distributed

throughout the cytoplasm and is not in the form of a definite chromatophore. Every cell possesses a single, eccentrically placed pyrenoid. In preparations stained with the safranin-gentian violet combination, the pyrenoid takes on a brilliant red coloration and the surrounding layer of starch is colored blue. The pyrenoid appears to be an entirely homogeneous body and not composed of lighter and darker regions, as Lutman (10) has shown to be the case in *Closterium*. On the other hand, the minuteness of the pyrenoid may possibly account for the failure to observe these details in its structure. A method devised by E. M. Gilbert, but as yet unpublished, in which a differentiation of the structure of the pyrenoid of *Sphaeroplea* was obtained by the use of safranin and Lichtgrün, was also tried, but no differentiation in the pyrenoid of *Tetradesmus* was observed. Surrounding the pyrenoid is a hyaline region which extends from the surface of the pyrenoid to the starch grains. This possibly may be a region that is composed of intermediate compounds in the formation of the starch grains, but this region failed to take any of the different stains used, although Timberlake (15) found that at times a part of it (in *Hydrodictyon*) stained with orange G. The starch granules surrounding the pyrenoid form a layer which is circular in outline and not angular as in *Hydrodictyon* (Timberlake) and *Closterium* (Lutman). FIG. 6 shows that there is some variation in the width of the starch layer and also that the outline of the starch ring may approach the ovoid but never the angular. The drawings also bring out the fact that the pyrenoid is not always in the center of the starch ring but may be towards one side. The starch layer is not a single unbroken ring but is composed of curved plates. FIG. 8 shows this segmentation of the starch layer. The determination of this point is an exceedingly difficult matter, although it may be noted again that the individual starch plates in *Scenedesmus* are easily observed. In the case of some of the older cells starch granules may be also found in the cytoplasm some distance from the pyrenoid (FIG. 7). These granules have been given the name of "stroma" starch by Klebs (8), but Timberlake (15) has shown that they are of pyrenoidal origin. The existence of the "stroma" starch may be taken as evidence of a somewhat pathological condition, since it is never found (at least in *Tetradesmus*)

in any except the old, yellow-colored cultures. The "stroma" starch is also produced in much larger quantities in the *Scenedesmus* cell than it is in the *Tetradesmus* cell.

The nucleus is usually at the inner side of the cell (FIG. 1), but it as well as the pyrenoid may lie in the long axis of the cell (FIG. 2). Frequently the nucleus and the pyrenoid are symmetrically placed in the long axis of the cell. There is always a single nucleole within the nucleus. The chromatin seems to have a very fine granular structure, and the only apparent difference between the cytoplasm and the non-nucleolar part of the nucleus is the greater density of the latter when the material is stained with Heidenhain's iron-alum-hematoxylin.

REPRODUCTION

Reproduction always takes place by the formation of autocolonies within the mother cell wall. The formation of zoöspores or motile gametes was never observed. In this respect the form resembles *Scenedesmus*, whose sexual reproduction is unknown.

The division of the nucleus was not observed with certainty, on account of the minuteness of the nucleus, but stages in the cleavage of the cell were found in sufficient abundance to warrant the assumption that the following is the correct description of the process.

The nucleus divides so that the daughter nuclei lie in a line parallel to the long axis of the cell, as shown by a cell containing two daughter nuclei (FIG. 9). This stage was found in great abundance, and the two daughter nuclei were always found at the inner side of the cell. Following this division of the nucleus comes a cleavage of the cytoplasm, so that each half of the protoplasmic mass contains a nucleus (FIG. 10*A* and 10*B*). This division takes place by the formation of a cleavage furrow from the outside toward the center. The process seems to be similar to that observed by Harper (7) in the spore formation of certain fungi and by Timberlake (16) in the swarm spore formation of *Hydrodictyon*. The daughter cells resulting from this division are two naked protoplasts which lie close to one another and are not separated by a wall. The pyrenoid does not divide during this process; consequently, at the end of the first cleavage one daughter

protoplast contains a pyrenoid and one does not. This fact can be determined with the greatest accuracy since the staining reaction of the pyrenoid makes it the most conspicuous structure in the cell. Hundreds of cells at this stage of development have been observed, and in every case the pyrenoid was easily distinguished in one of the daughter protoplasts while the other was empty. At first this cleavage without a division of the pyrenoid was thought to be an abnormality, but the abundance of cells in this condition and the failure to find a single case in which a pyrenoid appeared in each of the daughter protoplasts show that this is the normal condition.

The first plane of cleavage is usually approximately at right angles to the long axis of the cell (FIG. 10*A*), but soon after the cleavage the daughter protoplasts arrange themselves inside of the mother cell wall so that the original cleavage plane appears to be diagonal (FIG. 10*B*). The stimulus which leads to this twisting of one of the protoplasts upon the other is not known. A second division of the daughter nuclei now occurs. FIG. 11 shows this fully completed, the direction of the division, to judge by the position of the resting nuclei, always being parallel to the primary cleavage plane. There is some variation in the time at which this second division takes place; in some cases it occurs when the primary cleavage plane is only a few degrees from the transverse position, but in others the primary plane has come to lie at an angle of 45 degrees with its original position before the second nuclear division occurs. FIG. 11 shows that after the second nuclear division a single pyrenoid is still in evidence in one of the protoplasts while there is none in the other. The amount of starch surrounding the pyrenoid is approximately the same as that in the undivided cell, but this is not brought out in the figures, since material which is well stained for the nuclear structures does not show the starch about the pyrenoid. FIG. 10*B*, from material which was stained especially to bring out the pyrenoid, shows that after the first cell cleavage there is still considerable starch about the pyrenoid.

Following the second nuclear division there is a cleavage in each of the protoplasts. These cleavages seem to be usually simultaneous, but FIG. 12 shows a case in which the cleavage has been

completed in one of the daughter protoplasts and not in the other. The relation of the cleavage planes to one another shows that there are certain mechanical factors governing their position. It is well known [Wilson (20)] that in the cleavage of the animal egg changes often occur in the position of the cells with regard to one another. Surface tension seems to be one of the factors governing this change. In moss rhizoids, de Wildeman (18) found that the cross walls are always S-shaped in section, so that although the cross wall as a whole is placed diagonally, yet its junction with the outer walls of the rhizoid is at right angles. This curving of the cleavage planes where they meet the mother cell wall occurs in substantially the same manner in *Tetradesmus* (FIG. 13, 14).

One view of the young four-celled colony, shortly after the second cleavage, when seen from the side, is shown by FIG. 13, but when the young colony is seen in a plane at right angles to that shown in this figure, we observe the very different appearance shown in FIG. 13*A*. FIG. 13 shows that even after the four protoplasts of the young colony are formed, one and only one contains a pyrenoid. At this stage, or very shortly after, the old pyrenoid disappears (FIG. 14). This disappearance probably takes place quite rapidly, since no intermediate stages were found between those shown in FIG. 13 and 14. In no case was the pyrenoid recognizable at stages later than those of FIG. 13 and 14.

The changes that follow in the young colony might be well said to constitute a period of maturation. The maturation consists in an elongation of each of the daughter protoplasts until it extends the entire length of the mother cell. The protoplasts do not elongate so as to lie in one plane, but the two in one (which we may call the lower) half of the cell slip up over the two in the upper half. This slipping occurs along the diagonal plane of the first cleavage. A stage in this slipping is seen in FIG. 15, although the drawing fails to bring out the fact that a portion of each of the two upper cells is hidden by part of the lower pair of cells. When this elongation is completed, the daughter cells are arranged in two planes, so that only two cells may be seen in any lateral view (FIG. 16). The growth of the four daughter cells seems not to be an equal elongation of all parts, but rather an elongation of the end of each of the daughter cells farthest from the corresponding apex of the old

mother cell. As a result the nucleus of each daughter cell is not found in the center of the cell but nearer the end that was originally in contact with the apex of the mother cell wall. FIG. 15 shows this fact, but it must be borne in mind that a portion of the upper pair of cells is concealed by the lower ones. At the beginning of this elongation there is no pyrenoid present in any of the daughter protoplasts (FIG. 15). The further steps in the maturation of the daughter cells consist in the formation of pyrenoids and cell walls. The daughter cells are without pyrenoids until they have reached their full length, and then a pyrenoid suddenly appears in each (FIG. 16). Such an origin of pyrenoids *de novo* is contrary to the current conception, according to which a pyrenoid always arises by the division of a preëxistent pyrenoid but is in harmony, as will be later pointed out, with Timberlake's observations in *Hydrodictyon*. The formation of the new pyrenoid possibly may be a result of the metabolic activities of the nucleus, since the pyrenoid at its first appearance is often very close to the nucleus (FIG. 17). In other cases, possibly representing later stages, the pyrenoid is at a greater distance from the nucleus (FIG. 16). At about the same time as the appearance of the pyrenoid a cell wall is formed around each of the four protoplasts while they are still within the old cell wall.

The liberation of the daughter colony is through a longitudinal break in the mother cell wall. End views, such as those shown in FIG. 19 and 20, are especially favorable for studying the relation of the daughter coenobe to the mother cell wall. The opening through which the young colony escapes is a fissure that extends the whole length of the mother cell wall (FIG. 18). The cause of this rupture is probably the growth of the young colony within the old wall. It is not an irregular break but a definite longitudinal split, which is always at the side turned away from the other cells of the mother colony. After liberation the young coenobe is composed of cells which are of nearly full length but which are much more acicular than the mature cell (FIG. 17). The further history of the coenobe consists in the growth of the individual cells until they have assumed the shape characteristic of the adult stage.

DISCUSSION

Tetradesmus belongs to the family *Coelastraceae*, recently established by Wille (19). *Tetradesmus* shows a close relationship to *Scenedesmus*. The method of reproduction is essentially the same as that which occurs in *Scenedesmus*, the chief difference being that at the time of liberation from the mother cell wall the cells forming the coenobe in *Scenedesmus* become arranged in the form of a plate, while in *Tetradesmus* they remain rolled up. It seems probable that one form has been derived from the other, but there is little evidence as to the direction that the phylogenetic development has taken. There is also the possibility that these two forms have been derived from a common ancestor. *Tetradesmus* may have been derived from *Scenedesmus* through a loss of the tendency for the cells of the coenobe to unroll and spread out into a linear series after their liberation from the mother cell wall; or some colony of *Tetradesmus* may have developed this character of unrolling the cells in order to obtain an arrangement of the individual cells better adapted for photosynthesis.

Cytological study shows that these forms (*Tetradesmus* and *Scenedesmus*) are more closely related to *Hydrodictyon* and *Pediastrum* than has been usually supposed. In the last-named forms reproduction takes place by the formation of a more or less definite number of zcöspores, which then become arranged in the form of the mature colony while they are still inside the old mother cell wall or inside a gelatinous vesicle. In *Tetradesmus* and *Scenedesmus* there is a successive division into a definite number of uninucleate masses of protoplasm. These correspond to the zoöspores of *Hydrodictyon* and *Pediastrum* in every way except for the fact that they have no power of movement. We may easily think of these daughter cells in *Tetradesmus* and *Scenedesmus* as zoöspores which have lost the power of movement. The loss of power of motility of the zoöspores inside the mother cell wall is probably a step in advance of the condition in *Hydrodictyon*. There is also the possibility that this loss of movement of the zoöspores is connected with the smaller number of spores produced and the greater ease with which they get into their permanent positions. Reproduction in *Tetradesmus* is completed by a movement of the "zcöspores" into the position which they will occupy in the

mature colony, and then by the liberation of the young colony from the mother wall.

Another similarity between the young daughter cells in *Tetradesmus* and the swarm spores in *Hydrodictyon* is in the behavior of the pyrenoid. In *Hydrodictyon*, Timberlake (16) noted that after the swarm spores are formed by cytoplasmic cleavage, new pyrenoids appear as small red-staining bodies closely associated with the nuclei. This is exactly what takes place in *Tetradesmus* and gives us a further basis for considering the young daughter cells of *Tetradesmus* the morphological equivalents of the swarm spores of *Hydrodictyon*. As in *Hydrodictyon* also, the daughter cells at first have no cell wall, but a cellulose wall is formed after the daughter cells have settled down into the position which they will have in the adult colony.

SUMMARY

1. *Tetradesmus* is a distinct genus, and not a cultural form of *Scenedesmus*.

2. Reproduction takes place by the formation of non-motile cells (spores) by successive nuclear and cell divisions. These spores then become arranged in the form of the adult colony while they are still inside the old cell wall. The young colonies are liberated by the rupture of the mother cell wall.

3. The pyrenoids in the daughter cells arise *de novo* and not by the division of a preëxisting pyrenoid.

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Explanation of plate I

All figures, with the exception of FIG. 3, are of *Tetradesmus wisconsinensis*. They were drawn with the aid of the Abbe camera lucida, the drawing being at the level of the base of the microscope, and with the Leitz objective 1/16 and ocular 4. The magnification is about 2,200 diameters.

FIG. 1. Longitudinal section of colony.

FIG. 2. Surface view of colony, showing arrangement of cells.

FIG. 3. Colony of *Scenedesmus acutus* Meyen grown under the same cultural conditions as the colonies of *Tetradesmus* shown in FIG. 1 and 2.

FIG. 4, 5. Transverse sections of colonies.
FIG. 6. Various forms taken by the pyrenoid and the surrounding starch layer
FIG. 7. Cell showing "stroma" starch granules.
FIG. 8. Cell showing the pyrenoid with segmented starch ring.
FIG. 9. A cell after the first nuclear division.
FIG. 10A, 10B. Completion of first cell division.
FIG. 11. After the completion of the second nuclear division.
FIG. 12–14. Stages in the second cleavage of the cytoplasm.
FIG. 15, 15A. Beginning of elongation of the four daughter cells.
FIG. 16. Young colony inside of mother cell wall (lateral view).
FIG. 17. Young colony, immediately after liberation from mother cell.
FIG. 18. Empty mother cell walls after liberation of young colonies.
FIG. 19. End view of daughter colony, showing method of its liberation from mother cell wall.
FIG. 20. Transverse section of coenobe, showing young colony within the wall of one of the mother cells.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1912)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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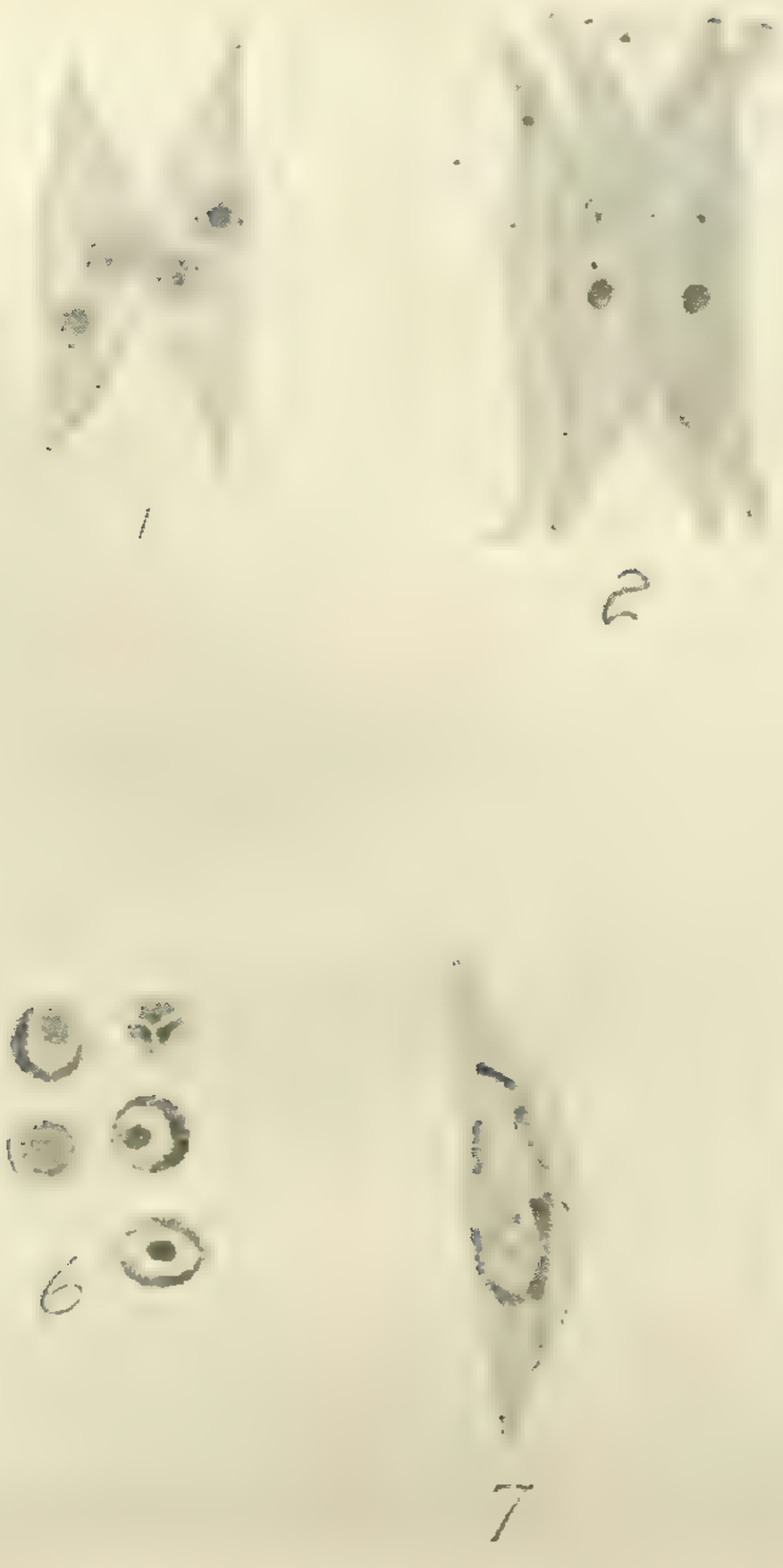

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Vol. 40 No. 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH 1913

Development of the peristome in Ceratodon purpureus

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INTRODUCTORY

In his recent work on the Bryophyta, Cavers ('11, p. 182) divides the Bryales, or true mosses, into the four following groups, based on distinctions emphasized by Fleischer: Tetraphidales, Polytrichales, Buxbaumiales, and Eu-Bryales. In this division the peristome is the organ from which the most important differential characters are derived. In the Tetraphidales and Polytrichales the teeth of the peristome are composed of entire cells; in the Buxbaumiales and Eu-Bryales they are composed of thickened cell walls. Leaving the Encalyptaceae out of consideration, the Eu-Bryales may be further divided, following the example of Philibert ('84, p. 67), into the Diplolepideae and the Haplolepideae. The Diplolepideae with few exceptions have two peristomes, while the Haplolepideae have single peristomes, if such structures are present at all.

In the Diplolepideae the two peristomes are derived from two concentric layers of cells in the opercular portion of the capsule. The development of the peristome has been described in several species of this group but is especially well known in *Funaria hygrometrica* (Goebel, '87, p. 188; Campbell, '05, p. 211) and *Mnium hornum* (Strasburger, '02, p. 491), which may be considered typical representatives. In both these species the outer peristomial layer is composed of thirty-two longitudinal rows of cells and the inner of sixteen rows. These rows form sixteen groups,

[The BULLETIN for February 1913 (40: 43–96) was issued March 18.]

each of which in cross section shows two cells of the outer layer lying opposite one cell of the inner layer. One of the sixteen teeth of the outer peristome arises in each group and is formed by the deposition of longitudinal bands of thickening upon the periclinal walls between the peristomial layers. These bands taper to fine points from a broader base. The band deposited by the two outer rows is of fairly uniform thickness throughout and extends as a continuous layer across the thin radial and transverse walls separating the cells. The band deposited by the single inner row corresponds in position and in width with the one just described and is of about the same thickness. Thickening is deposited also upon the transverse walls separating the cells of this row. Upon the disappearance of the portions of the walls which have remained thin the teeth show their mature condition. Each tooth bears upon its inner surface a series of transverse ridges corresponding to the thickened transverse walls, while the smooth outer surface shows the vestiges of the transverse and radial walls, the latter appearing as a zigzag median line running the entire length of the tooth. The delicate inner peristome is formed by deposits of thickening upon the inner walls of the inner peristomial layer. Toward the base the thickening is continuous, but in the upper part it is in the form of isolated longitudinal bands, definite in position and in number. At maturity the continuous portion forms the basilar membrane of the peristome, while the isolated bands form the segments and the cilia.

In the Haplolepideae the peristome is likewise derived from two concentric layers of cells, but in this case each tooth is formed by one row of outer cells and two rows of inner cells and therefore shows the zigzag longitudinal line on the inner surface instead of on the outer. In the opinion of Philibert ('88, p. 68), the single peristome of this group is homologous with the inner peristome of the Diplolepideae. This being the case it is evident that the large-celled inner peristomial layer in the Diplolepideae would be homologous with the large-celled outer layer in the Haplolepideae. The subject of the present study, *Ceratodon purpureus*, is a characteristic member of the Haplolepideae, and many of the features which the peristome shows, in development as well as in structure, are undoubtedly common to other species of the group.

The material, which was collected in the vicinity of New Haven, Connecticut, was studied by means of microtome sections.

The mature peristome of *Ceratodon purpureus* has been repeatedly described in taxonomic treatises, but a brief account of its peculiarities will make the description of the development more intelligible. It consists of sixteen teeth which arise from a continuous basilar membrane. Each tooth is divided almost to the base into two slender tapering branches, which show much the same structure throughout their entire length (FIG. 17, 18). The outer portion of each branch forms a subcylindrical ridge, distinctly contracted at its union with the inner portion, which is broader and more flattened toward the base. Four or five corresponding transverse ridges extend across the branches of each tooth, being close together at the base but farther apart toward the apex. They correspond with the transverse walls of the outer peristomial layer. On the inner surface also vestiges of transverse walls can be detected, but these are unaccompanied by ridges (FIG. 19, 24). Just above the basal undivided portion of each tooth one or more of the transverse ridges extend across from branch to branch, thus leaving median perforations (FIG. 21). The basal portion is especially thick and bears several crowded transverse ridges, which in longitudinal section give the tooth a serrated appearance (FIG. 24). The entire surface of the teeth is covered over with minute spicules. The basilar membrane of the peristome is in the form of a hollow cylinder, sixteen cells in circumference and three or four cells high, representing a part of the outer peristomial layer. The thickened walls in this portion of the peristome are smooth throughout.

The early development of the sporophyte in *Ceratodon purpureus* was studied by Kienitz-Gerloff ('78, p. 42), who detected in very young stages a two-sided apical cell cutting off two rows of segments, just as in other members of the Eu-Bryales. Each of these segments, as he further showed, soon became divided into quadrants by an anticlinal wall and then underwent divisions according to the so-called "Grundquadrat" or "fundamental square" method described below. The embryonic development of *Ceratodon* is discussed also by Goebel ('87, p. 178), but the most complete account of the process is that published by Kuntzen ('12), who, however, pays but little attention to the peristome.

The first developmental study of the peristome in *Ceratodon purpureus* was made by Lantzius-Beninga ('50, p. 574), who compared it with the peristome of *Trichostomum tortile*, now known as *Ditrichum tortile*. In his figures of young transverse sections ('50, *pl. 66, f. 40, 41*) he indicated the two layers of cells which give rise to the peristome but represented each layer as being composed of sixteen cells, those of the inner layer alternating with those of the outer. This was proved to be incorrect by Kienitz-Gerloff ('78, p. 44), who stated that, while the outer layer showed sixteen cells in section, the inner showed from twenty to twenty-four cells and that normally two cells of the outer layer bounded three cells of the inner. He showed further that the peristome developed in the amphithecial portion of the sporophyte and that the peristomial cells represented the fourth and fifth layers from the outside except in the region of the operculum, where they represented the third and fourth layers. The studies of Lantzius-Beninga and Kienitz-Gerloff have to do mainly with the region where the peristome is formed and give but few details about the actual development of the teeth, and the same thing is true of most of the work which has been done upon the peristomes of other Haplolepideae.

In the present paper the account of the peristome will be divided into two parts. In the first the origin and development of the two peristomial layers will be described; in the second the deposition of the thickenings which constitute the bulk of the teeth will be considered.

DEVELOPMENT OF THE PERISTOMIAL LAYERS

As earlier writers have pointed out, the divisions which take place in the segments cut off from the apical cell of the young sporophyte proceed with great regularity, whether the segment is destined to form a part of the stalk or of one of the regions of the capsule. This regularity is characteristic not only of an individual species of the Bryales but of the group taken as a whole. It has been recently emphasized by Kuntzen ('12) in the particular case of *Ceratodon purpureus* and becomes strikingly evident through the study of the operculum and peristome. The opercular segments, like those which go to form the spore-case, are in

the form of half-cylinders, which become divided into quadrants by anticlinal walls. Cross sections through young sporophytes just below the apical cell show this condition clearly (FIG. 1, 2). It is in the quadrants that the division takes place according to the "fundamental square" method. If transverse walls are left out of consideration each quadrant divides by an anticlinal wall, extending as a curved surface from one of the side walls to the outside wall, into two cells (FIG. 3), a smaller triangular cell (as seen in section) and a larger four-sided cell. The latter soon divides by a periclinal wall into an outer and an inner cell (FIG. 4). According to Kuntzen ('12, p. 19) the segments in the stalk sometimes divide in the way just described and sometimes by means of a periclinal wall followed by an anticlinal wall in the outer of the two cells thus formed. In the spore-case he finds the second method only but admits that perhaps the first method is sometimes followed. In either case, after the rearrangement of the walls, the cross section shows four inner cells, the "fundamental square," surrounded by eight outer cells. The inner cells constitute the endothecium and the outer cells the amphithecium. A similar arrangement of the cells can be demonstrated in the young sporophytes of most of the higher bryophytes.

In the next stage of development the amphithecial cells divide by periclinal walls, thus giving rise to two layers of eight cells each (FIG. 5). The inner cells, shaded in the figure, will develop into the inner peristomial layer. The corresponding layer in the spore-case gives rise to the outer spore-sac. It is upon the periclinal walls separating the two amphithecial layers that the teeth of the future peristome will be deposited. Marked differences occur in the endothecium and amphithecium with respect to the relative rate of cell division. In the region of the annulus the inner peristomial layer completes its divisions before the endothecium has passed beyond the four-celled stage. In the region of the peristomial teeth the division may be simultaneous or the endothecium may divide first. In the portion of the operculum above the peristome the inner amphithecial layer never passes beyond the eight-celled stage.

In the region of the teeth, after the stage shown in FIG. 5, the cells of the outer amphithecial layer divide by anticlinal walls,

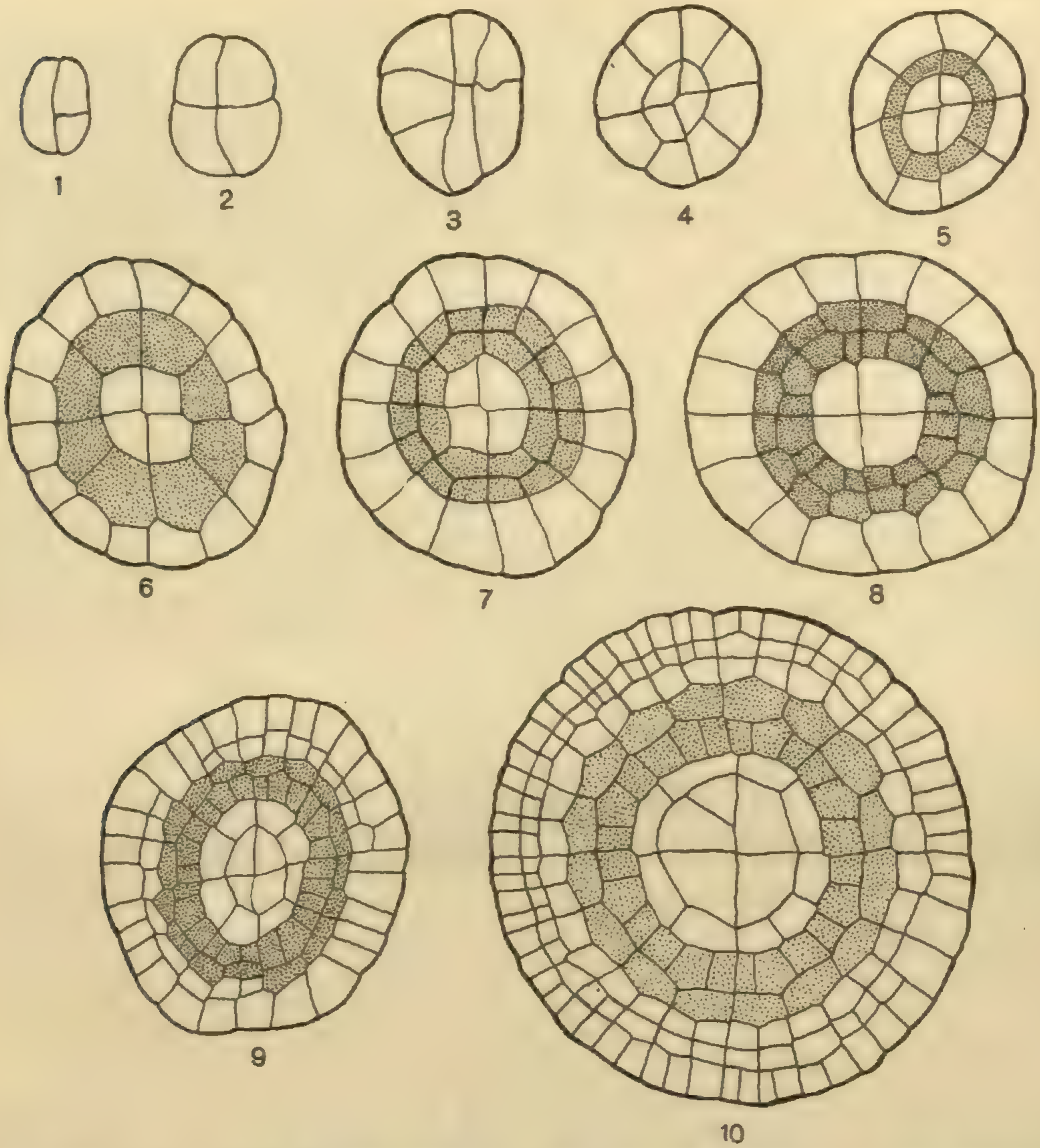


FIG. 1–10. Cross sections through the opercular region of young capsules, showing successive stages of development; peristomial layers stippled, ×300. 1 and 2, division of segments into quadrants; 3 and 4, establishment of amphithecium and endothecium; 5, establishment of inner peristomial layer; 6, division of cells in outer amphithecial layer by anticlinal walls; 7, establishment of outer peristomial layer; 8 and 9, division of cells in inner peristomial layer by anticlinal walls; 10, continuation of divisions in outer amphithecial layer and in endothecium.

thus raising the number of cells in this layer to sixteen (FIG. 6). Each of the sixteen cells then divides by a periclinal wall so that two layers of sixteen cells each are formed (FIG. 7). The inner layer represents the outer peristomial layer and undergoes no further divisions. It will be noted that the eight pairs of cells in this layer lie opposite the eight cells of the inner peristomial layer. In the spore-case the layer homologous with the outer peristomial layer gives rise to most of the photosynthetic tissue

including the large intercellular space. The condition shown in FIG. 7 corresponds closely with figures by Kienitz-Gerloff ('78, *pl. 1, f. 25b*) and Kuntzen ('12, *f. 10*), representing sections through the spore-case. The eight cells of the inner peristomial layer now proceed to divide in a very peculiar way. In each of these cells an anticlinal wall appears (FIG. 8), cutting off either to the right or left a small cell from one fourth to one third as wide as the parent cell. This is followed by a second anticlinal wall cutting off a similar small cell on the other side of the parent cell (FIG. 9). In this way the inner layer becomes divided into twenty-four cells, each group of three corresponding with one of the pairs of cells in the outer layer. No further divisions are undergone by these twenty-four cells. The arrangement of cells just described seems to be even more constant than Kienitz-Gerloff implies, since he states that the number of cells in the inner layer may vary from twenty to twenty-four.

The endothecium and the peripheral layer of the amphithecium play no direct part in the development of the peristome, and yet an account of the cell divisions that take place in them will not be wholly out of place. The divisions in the peripheral layer are not altogether definite. After the sixteen-celled stage, still shown in FIG. 8, the cells divide by anticlinal and periclinal walls without following a rigid system, adjacent cells often dividing in different ways (FIG. 10). In all cases, however, the final condition is essentially the same, three concentric layers of cells being produced. The outermost layer is composed of (approximately) 128 cells, the middle layer of 64 cells, and the innermost of 32 cells. In the region of the annulus, however, only two layers of cells are formed, thus allowing for the extraordinary development of the annular cells (FIG. 13, 25, 26). The peripheral layers of cells form the operculum, the external walls of the outermost layer becoming strongly thickened.

The divisions in the endothecium of the opercular region are essentially like those in the spore-case, as described and figured by Kuntzen ('12). After the four-celled stage, shown in FIG. 8, division takes place according to the "fundamental square" method, eight outer cells and four inner cells being thus formed (FIG. 9). The inner cells repeat this method of division (FIG. 10),

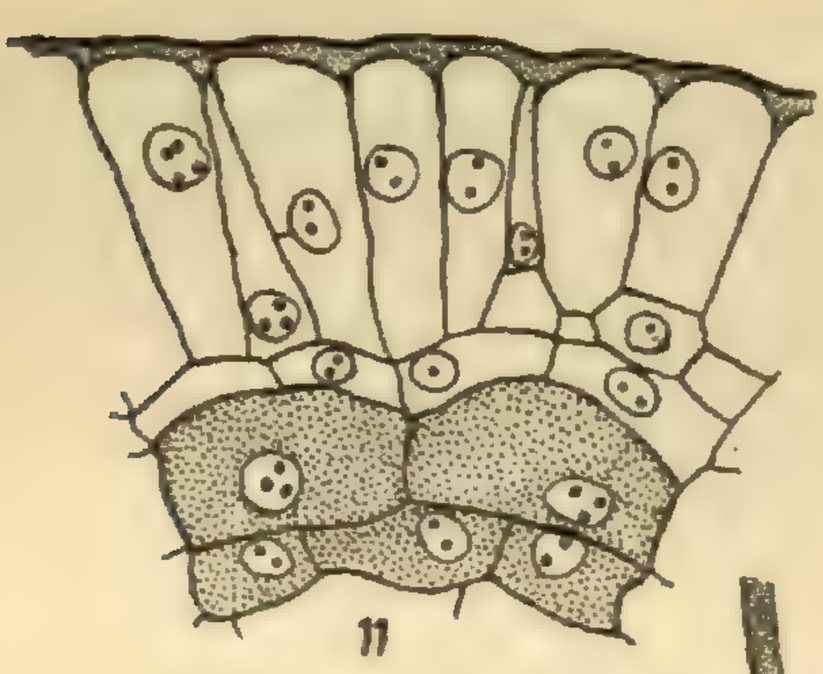
while the cells of the outer layer divide by anticlinal walls in a more or less indefinite manner. When the capsule approaches maturity the endothecial tissue within the peristome consists of a relatively small number of large and thin-walled cells, this tissue of course being the continuation of the columella and the sporogenous tissue in the spore-case.

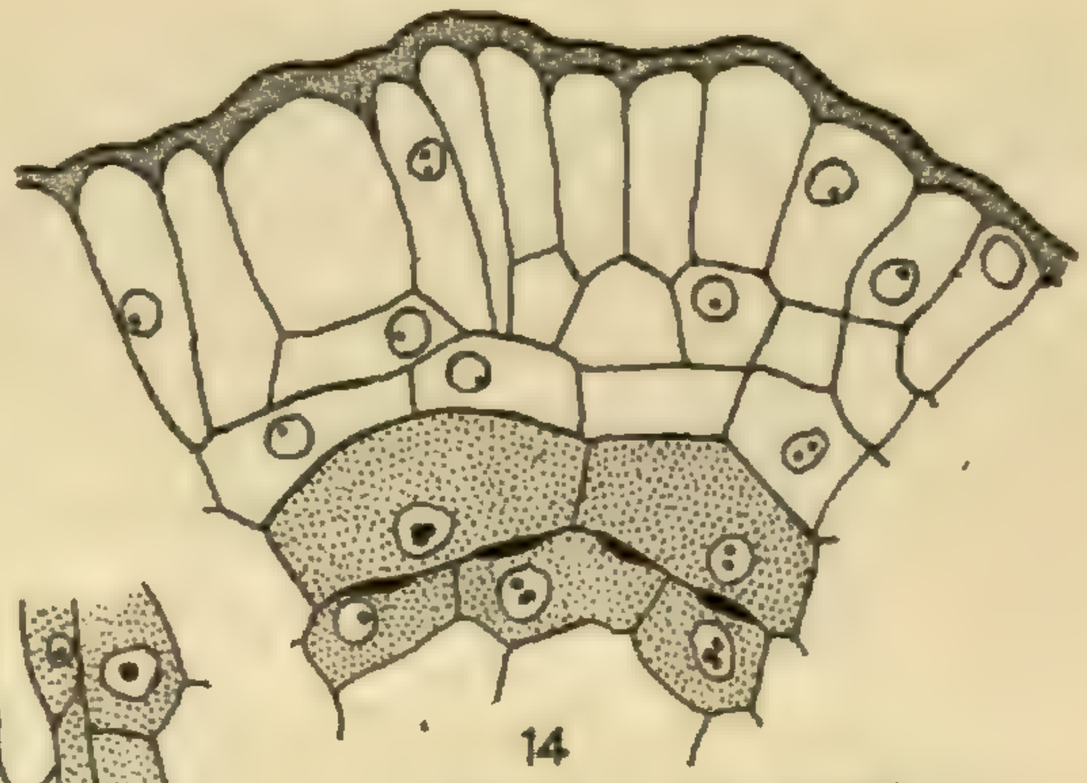
While the segments have been undergoing the anticlinal and periclinal divisions just described, divisions by transverse walls have also occurred in the various layers. Apparently they occur in a rather indefinite way and vary in different parts of the capsule (see Kuntzen, '12, p. 22, etc.). In the peristomial layers transverse walls are especially numerous toward the base and tend, in this region at least, to be more numerous in the outer layer than in the inner (FIG. 13). Toward the apex they are more numerous in the inner layer (FIG. 12).

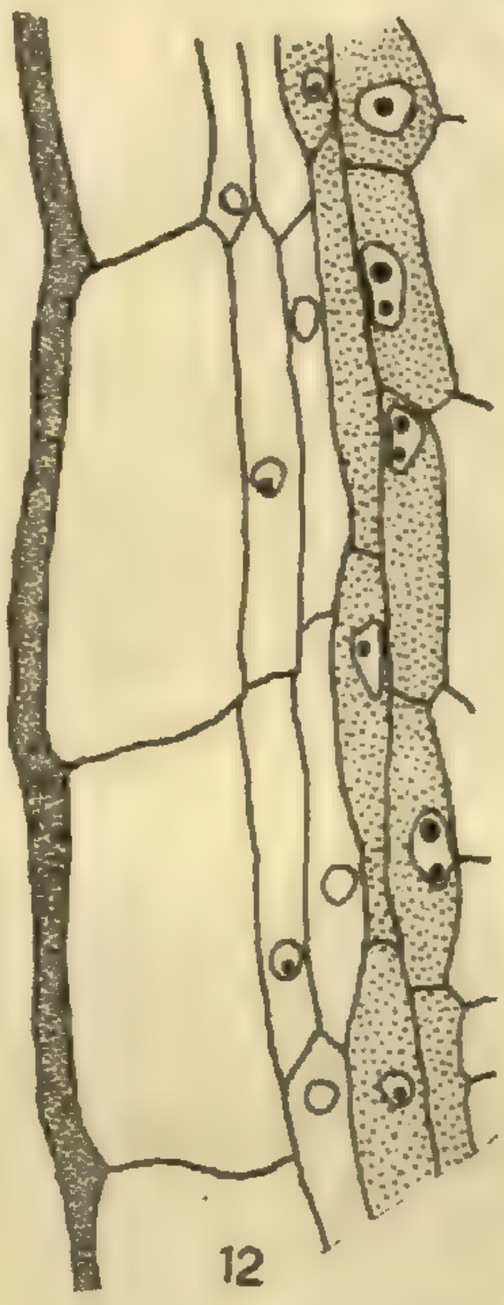
DEPOSITION OF THE PERISTOMIAL THICKENINGS

The forty rows of cells taking part in the formation of the peristome may be naturally divided into eight groups of five rows each. In each group three rows of the inner peristomial layer correspond with two rows of the outer layer. A cross section of such a group before the deposition of thickening is shown in FIG. 11. A group gives rise to two teeth of the peristome and the same processes are repeated in each group. The peristomial cells, before the thickenings are laid down, contain dense cytoplasm and small nuclei with several nucleoli but are usually without vacuoles (FIG. 11–13). In the upper part of the peristome, where the teeth are divided into branches, eight regions of thickening can be distinguished in each group, the four of the outer layer corresponding with the four of the inner layer. Two regions belong to each cell of the outer layer and to the median cell of the inner layer, while one region belongs to each lateral cell of the inner layer. The thickening first makes its appearance in the inner layer (FIG. 14) but soon becomes evident in the outer layer as well (FIG. 15, 16). If two corresponding regions are regarded as forming a single strand, each group will then form four strands, representing the four branches of the two peristomial teeth.

The deposition of thickening begins in the basal portion of







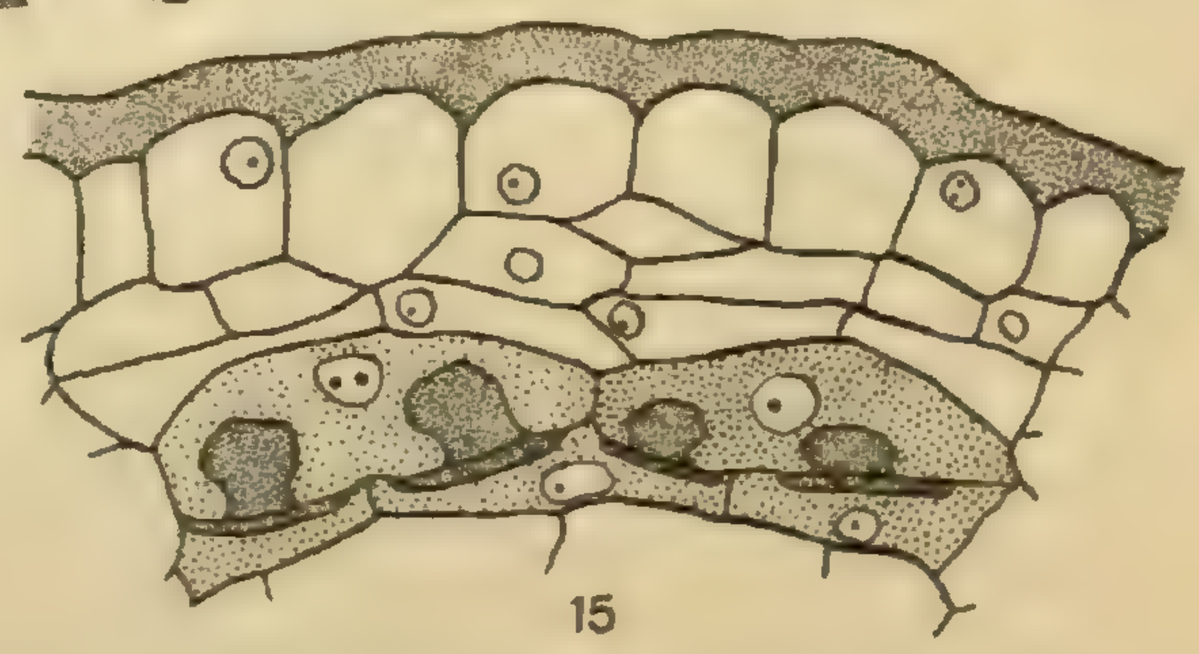


FIG. 11–16. Cross and radial sections through the amphithecial tissues of older capsules, ×300. 11 and 12, showing the peristomial layers in the region of the teeth, just before the deposition of the thickenings; 13, showing the same stage in the annular region; 14–16, showing early stages in the development of the thickenings.

the peristome but follows essentially the same method throughout the branches of the teeth. The portions of the strands deposited by the inner peristomial cells are broader than those deposited by the outer cells. They are therefore more conspicuous at first, but become less so later on. This is due to the fact that the inner portions of the strands develop to a slighter extent and in thickness only, while the outer portions give rise to the thick

subcylindrical ridges already noted in the mature teeth (FIG. 17). The differences between the inner and outer portions become less and less marked toward the apices of the branches (FIG. 18). Upon the transverse walls in the outer peristomial layer thickenings are also deposited. These are continuous with the thickenings on the inner wall and give rise to the transverse ridges of the mature teeth (FIG. 19). In a young stage, seen in tangential section (FIG. 20), the transverse thickenings apparently broaden out the outer longitudinal ridges, and the same appearance is even more

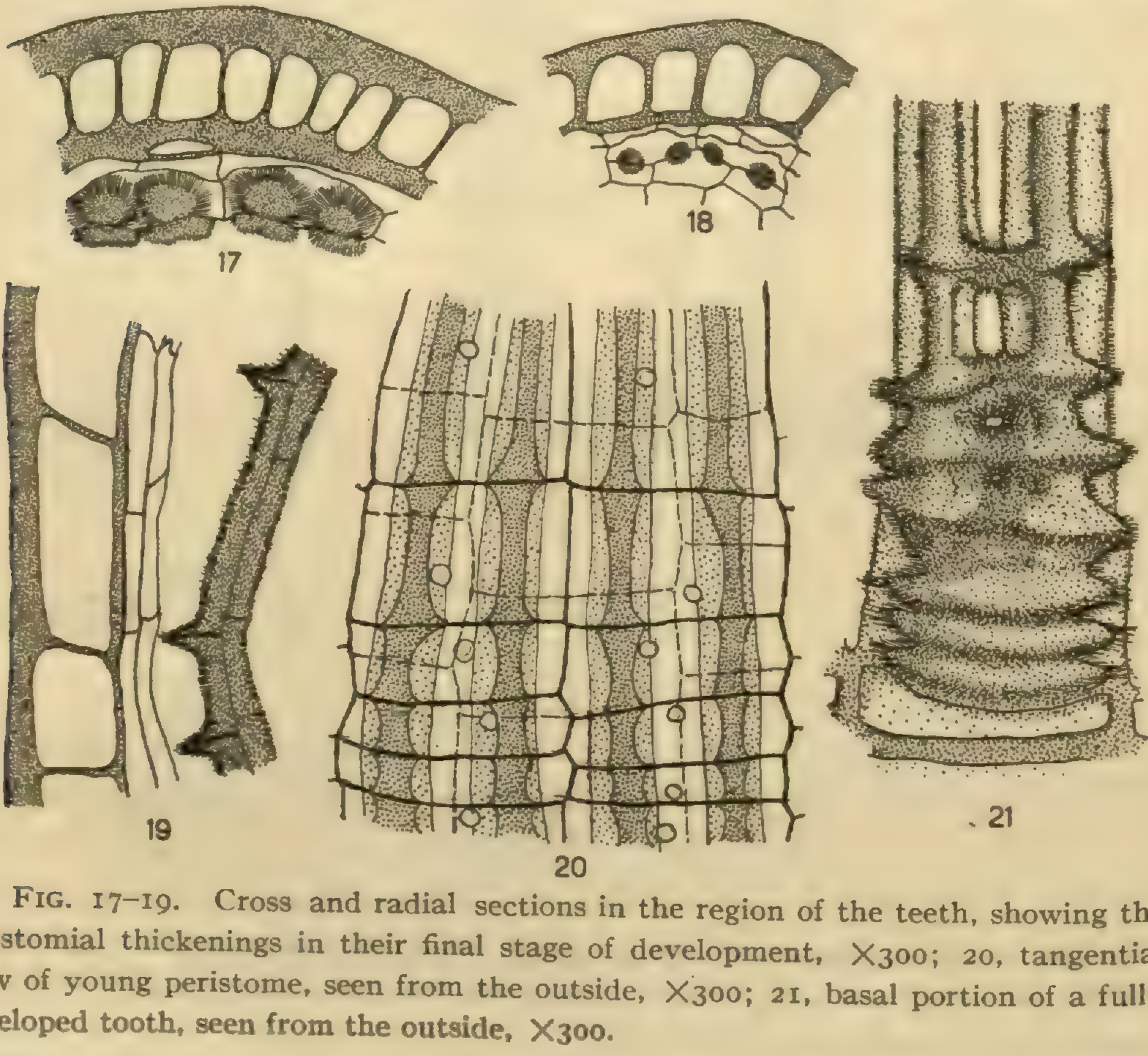


FIG. 17–19. Cross and radial sections in the region of the teeth, showing the peristomial thickenings in their final stage of development, ×300; 20, tangential view of young peristome, seen from the outside, ×300; 21, basal portion of a fully developed tooth, seen from the outside, ×300.

striking in an older tooth (FIG. 21). Toward the base of the branches the transverse ridges grow wider and wider until finally some of them span the distance between the branches and coalesce, thus forming a continuous ridge across the entire tooth. Below this region the ridges are all continuous. If Philibert's ideas regarding the homologies of the peristomial layers are accepted, it becomes evident that the transverse ridges just described correspond with those present on the inner surface of the outer peristome in the Diplolepideae. In *Ceratodon purpureus*, however, the

ridges become adherent to the inner walls of the peristomial layer instead of to the outer walls, as is the case in the Diplolepideae. In the lower part of a tooth the longitudinal ridges on the outside also show an increase in thickness until they extend more than half way across the cavities of the cells in which they are deposited (FIG. 22, on left). In the basal undivided portion of a tooth these ridges finally coalesce and form a single broad ridge (FIG. 22, on right, 23), beyond which the transverse ridges project for only a short distance (FIG. 24, 25).

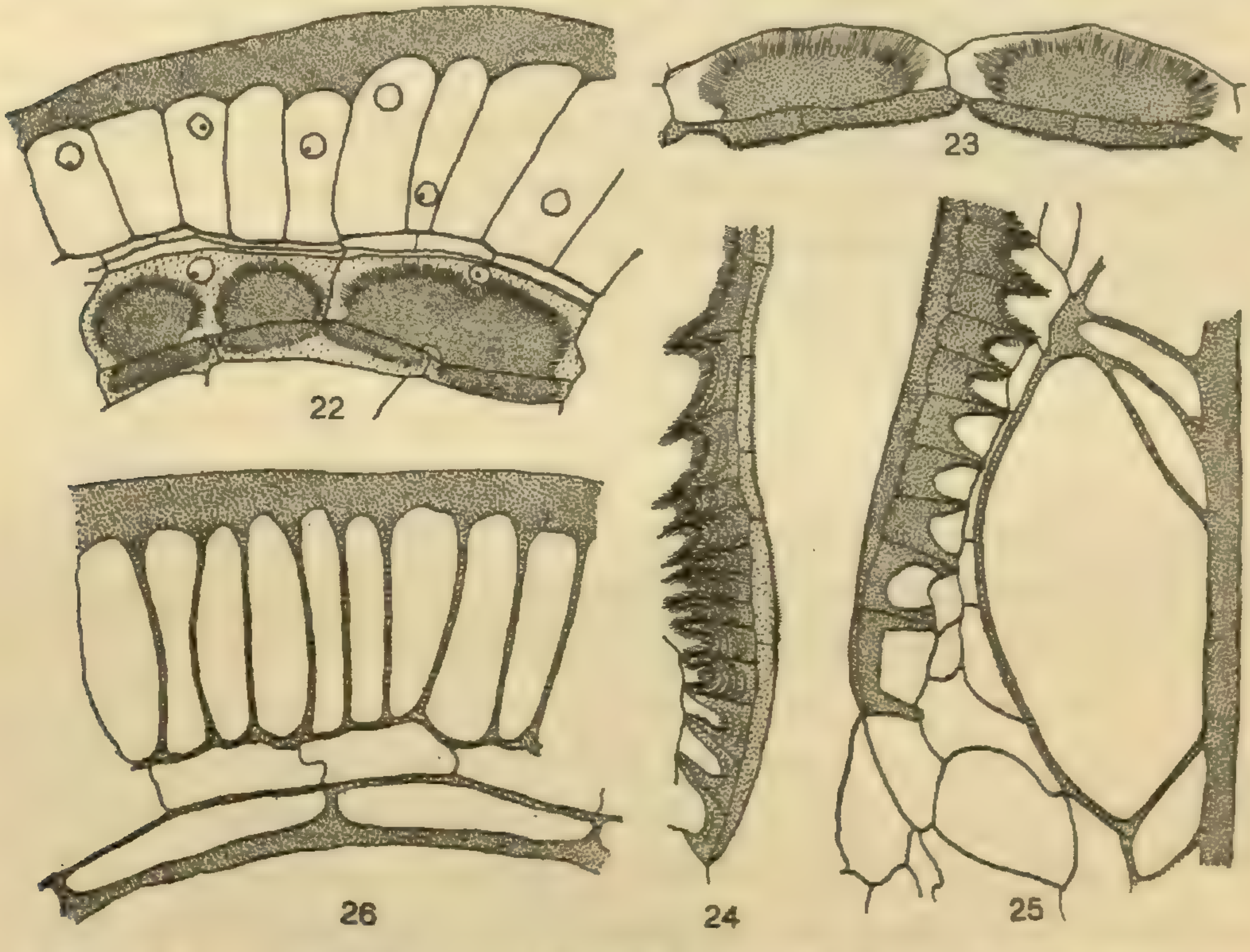


FIG. 22–26. Cross and radial sections in the region of the basal portion of the peristome, ×300. 22 and 23, showing the basal portions of two teeth; 24 and 25, showing the same, together with the basilar membrane; 26, showing the basilar membrane only.

The thinner deposits of thickening formed by the inner peristomial cells gradually increase in width toward the base until they finally meet and coalesce at the radial walls between the two rows of cells (FIG. 17, 22, 23). The vestiges of the radial walls form a zigzag longitudinal line on the inner surface of the tooth, and not on the outside as in the Diplolepideae. This line is of course much shorter than in *Funaria hygrometrica* and *Mnium hornum*, in which the teeth are not divided into branches. No

transverse ridges are developed in the inner peristomial layer, but the vestiges of the walls remain visible as fine lines.

When the strands of thickening have reached their full size, the spicules of cell wall substance are deposited in immense number over the entire surface (FIG. 17–19, 21–25). Those formed by the outer cells are considerably longer than those formed by the inner cells, but all are exceedingly minute.

The cells which form the basilar membrane of the peristome acquire thick walls also, but the deposits of thickening differ from those which form the teeth. This is especially true of the outer peristomial layer where the thickening extends almost evenly over the inner walls, the radial walls, and the transverse walls but leaves large pits on the outer walls (FIG. 25, 26). In the inner peristomial layer the thickening is less pronounced and forms a continuous layer over the outer wall. Throughout this portion of the peristome the surface of the thickening remains smooth, no spicules being developed. The basilar membrane lies just within the large cells of the annulus (FIG. 25).

Soon after the spicules have been deposited upon the teeth the peristomial cells dry up, the thin parts of the walls shrivel away and disappear, and the teeth become free. In the basilar membrane the pits in the outer wall now appear as perforations. At the same time the operculum becomes separated, and the endothecial tissues disintegrate. The finer structure of the mature peristome and the hygroscopic movements which it executes are fully described by Steinbrinck ('97).

SUMMARY

The original amphithecium, showing eight cells in cross section, divides by periclinal walls into an inner and an outer layer.

The inner peristomial layer develops from the inner amphithecial layer, undergoing division by anticlinal walls until it is composed of twenty-four longitudinal rows of cells.

The outer peristomial layer develops from sixteen longitudinal rows of cells cut off by periclinal walls from the outer amphithecial layer, after its eight rows have been divided by anticlinal walls; the outer peristomial layer undergoes no further divisions by anticlinal walls.

Ridges of thickening, representing the future teeth, are laid down upon the periclinal walls between the two peristomial layers.

The cells of the peristomial layers form eight groups, each composed of two rows of cells of the outer layer and three rows of the inner layer. Each group gives rise to two teeth.

In the upper part of each group eight deposits of thickening are laid down in four strands, representing the four branches of the two teeth; in the lower part only two strands are formed, representing the basal undivided portions of the teeth.

In the outer peristomial layer thickenings are deposited also upon the transverse walls, representing the transverse ridges of the teeth.

In the undivided basal portion of each tooth a fine median longitudinal line on the inner surface represents the vestiges of the radial walls between two rows of peristomial cells.

In the basilar membrane the thickening of the walls in the outer peristomial layer is uniform except in case of the outer walls.

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A note on the significance of sugar in the tubers of Solanum tuberosum

O. Butler

(with plate 2)

Sugar accumulates in the tubers of the potato during the rest period when they are subjected to low temperatures, and, at least this is the general opinion, at the time of germination. In other words sugar develops at a time when the various vitalistic phenomena are inactive and again when the life processes are proceeding actively.

I

During the rest period two factors influence the accumulation of sugar in the tubers of the potato: temperature and oxygen supply. Both these factors may act independently of one another or additively. I shall, however, for convenience, consider them separately.

Temperature

The effect of temperature on the accumulation of sugar in potato tubers was studied years ago by Müller-Thurgau* and, as the results he obtained have not been disproved, I will simply briefly review them, adding some data of my own in confirmation.

The belief is very tenaciously rooted in the popular mind that a potato becomes sweet only when it is frozen. A frozen potato never becomes sweet, moreover a potato does not freeze at 0° C., whence probably the origin of this notion. Potatoes, in fact, may be stored at 0° C. for a period of time without being injured, Müller-Thurgau having kept them at this temperature in some of his experiments for as long as one hundred days..

Taking 0° C., then, as the lowest temperature at which potatoes may be safely stored, Müller-Thurgau found that when the rates of sugar accumulation at 0° C., 3° C., and 6° C. were compared

* Müller-Thurgau, H. Ueber Zuckeranhäufung in Pflanzentheilen in Folge niederer Temperatur. Landw. Jahrb. 11: 757–828. 1882.

the following relation was approximately obtained, x being the amount of sugar formed at 0° C.

$$\frac{x}{3.6} \text{ at } 3° \text{ C. and } \frac{x}{7} \text{ at } 6° \text{ C.}$$

He also observed that individual potatoes of the same variety showed marked variations in the rapidity with which sugar accumulated in their tissues, but that if at 0° C. sugar accumulated in relatively small amount in the tubers of a given variety, then no accumulation would occur at 6° C., and conversely, if sugar was formed rapidly at 0° C., then a temperature of 8° C. would be usually necessary to effect the same result. At 10° C. sugar never accumulated.

The fact brought to light by Müller-Thurgau that different varieties of potatoes exhibit differences in the rapidity of sugar accumulation is readily confirmed, as the following table shows.

TABLE I

SUGAR ACCUMULATION IN DIFFERENT VARIETIES OF POTATOES STORED AT 1°–5° C. FOR 28 DAYS

	Percentage reducing sugar in potatoes*		
Variety of potato	At beginning of experiment	After 28 days	Daily increase
Triumph	0.59	0.97	+0.013
American Wonder	0.88	0.85	−0.001
Rural New Yorker	0.17	1.01	+0.03
Early Ohio	0.15	1.25	+0.039
Early Rose	0.42	0.86	+0.015
Red Alcohol	0.10	1.42	+0.047
Rusty Rose	0.43	1.10	+0.023
Blue Victor	0.53	1.22	+0.024
McCormick	0.43	1.04	+0.021

Müller-Thurgau found, taking his results for 3° C., as these more nearly approach the average temperature at which the potatoes were stored in the above experiment, that the daily increase during a period of 30 days was 0.021 per cent, results which are of the same order as those given in the above table.

According to Müller-Thurgau sugar does not accumulate in resting potatoes when they are stored at a temperature of 8° C.

* All the quantitative determinations given in this paper were kindly made for me by Mr. F. B. Morrison, Madison, Wis.

It would also appear as if potatoes stored at 8°–10° C. not only do not accumulate sugar but do not reconvert it into starch as occurs at higher temperatures (this is Müller-Thurgau's view of the matter), or dispose of it through respiratory activity. The amount of sugar present in the potatoes when they are placed in storage at this temperature suffers little change. This fact is clearly shown in the following table:

TABLE II

CHANGES IN SUGAR CONTENT OF DIFFERENT VARIETIES OF POTATOES AFTER STORAGE AT 8°–11° C. FOR 34 DAYS

	Percentage reducing sugar in potatoes		
Variety of potato	At beginning of experiment	At end of 34 days	Increase
Triumph	0.59	0.43	−0.16
American Wonder	0.88	0.65	−0.23
Rural New Yorker	0.17	0.24	+0.07
Early Ohio	0.15	0.16	+0.01
Early Rose	0.42	0.31	−0.11
Red Alcohol	0.10	0.17	+0.07
Rusty Rose	0.43	0.38	−0.05
Blue Victor	0.53	0.45	−0.08
McCormick	0.43	0.39	−0.04

When potatoes containing sugar are stored at 20° C. the sugar gradually disappears due to increased respiration and reconversion to starch (Müller-Thurgau). However, if the potatoes remain sufficiently long at 20° C. for germination to be initiated, an increase in the sugar content is liable to take place. The aberrant results in the following table may be accounted for on these grounds.

TABLE III

LOSS OF SUGAR IN POTATOES STORED AT 20° C. FOR 21 DAYS

	Percentage reducing sugar in potatoes		
Variety of potato	At beginning of experiment	At end of 21 days	Decrease
Triumph	0.59	0.22	−0.37
American Wonder	0.88	0.05	−0.83
Rural New Yorker	0.17	trace	−0.17
Early Ohio	0.15	0.08	−0.07
Early Rose	0.42	0.13	−0.29
Red Alcohol	0.10	0.15	+0.05
Rusty Rose	0.43	0.37	−0.06
Blue Victor	0.53	0.40	−0.13
McCormick	0.43	0.65	+0.22

When potatoes containing sugar are placed at 20° C. respiration immediately increases to a very marked extent, while in the case of similar potatoes containing none or only traces of sugar the increase is very slight. The respiration of the potatoes containing sugar, while very rapid at first, reaches a maximum in one and a half or two days, and then gradually decreases until it becomes equal to that of potatoes containing little or no sugar.

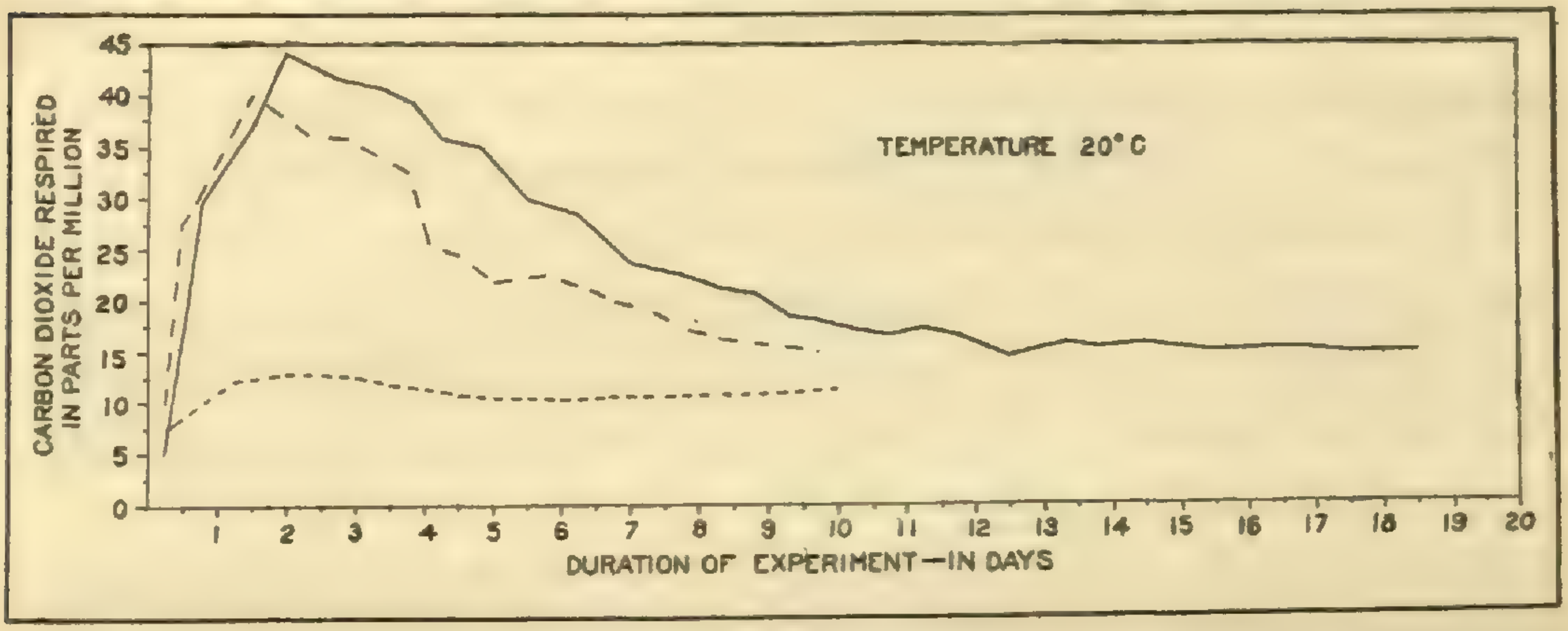

FIG. 1. (After Müller-Thurgau.) Respiration of potatoes containing different amounts of sugar at 20° C. Legend:

——— Respiration of 50 potatoes containing an average of 1.7814 per cent reducing sugar.

– – – – Respiration of 50 potatoes containing an average of 1.464 per cent reducing sugar.

------ Respiration of 50 potatoes containing none or only traces of reducing sugar.

The results obtained by Müller-Thurgau are very striking and are well illustrated in the above graph taken from his work. (FIG. 1.)

It is perfectly obvious that the respiratory activity of potatoes

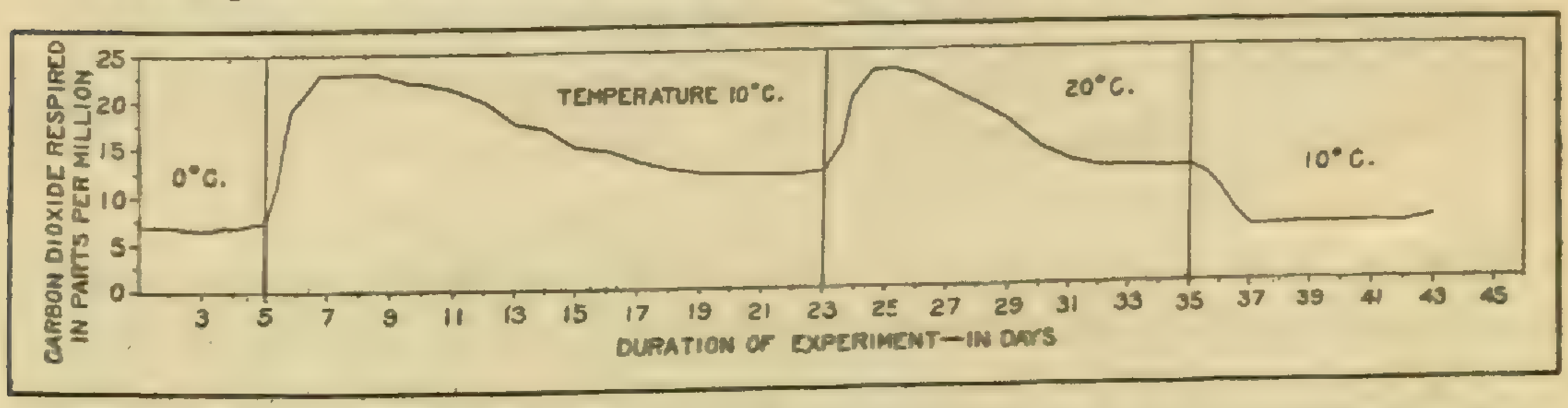

FIG. 2. (After Müller-Thurgau.) Influence of change of temperature on respiratory activity of potatoes initially rich in reducing sugar.

is more influenced by the presence of sugar than by temperature. Sugar is essentially a limiting factor. This is well illustrated in the second graph (FIG. 2), in which the respiratory activity of

potatoes stored at 0° C., then at 10° C., then at 20° C., and again at 10° C., is compared. It will be seen at once that when potatoes were placed at 10° C. respiration immediately increased, then fell gradually until the potatoes were placed at 20° C., when it rose again to the same maximum as before but decreased more rapidly and, after being placed at 10° C. again for a short while, became almost equal to what it had been when the potatoes were stored at 0° C. It should be noted that the experiments just recorded were begun after the potatoes had been kept for 28 days at 0° C., i. e., the potatoes used were rich in sugar.

Müller-Thurgau believed that when potatoes containing sugar were placed at 20° C. the sugar that disappeared was partly used up in respiration, and partly reconverted to starch, as the disappearance of the sugar could not be all accounted for by the amount of carbon dioxide exhaled. In performing his experiments Müller-Thurgau sliced his potatoes longitudinally, using one half for immediate analysis and the other for analysis at the end of the experiments. Under these conditions, even when the proper corrections for loss of weight due to evaporation are made, some of the sugar will undoubtedly go to the formation of the suber produced along the cut surface, and not unlikely, the increase in the percentage of starch obtained was due to the hydration of the cellulose that had been recently or was being laid down. The question, however, is deserving of further study.

OXYGEN

We have seen that during the rest period sugar may be made to accumulate in potatoes by storing the tubers at temperatures varying between 0° C. and 6° C., but that at 8°–10° C. the amount of sugar (when any was present) remained stationary. The relation of the oxygen supply to the accumulation of sugar in potatoes therefore may be studied conveniently at 8°–10° C. In the experiment which I have performed on this subject I used the Sir Walter Raleigh variety of potato and the tubers were placed in tubulated bell jars of the usual pattern:

Bell jar no. 1 contained 1,934 grams of potatoes, and the tubules were stopped with cotton, thus allowing a free diffusion of air.

Bell jar no. 2 contained 1,936 grams of potatoes and was connected with a water siphon by means of which approximately 8 per cent of the volume of the contained air was renewed daily.

Bell jar no. 3 contained 1,897 grams of potatoes and was connected with a water siphon by means of which approximately 0.8 per cent of the volume of the contained air was renewed daily.

Within a few days the air in all the bell jars became saturated with water vapor. The experiment was discontinued after 90 days, when the potatoes in the different bell jars were analyzed and found to contain sugar as follows:

Bell jar no. 1, 0.09 per cent sugar; bell jar no. 2, 0.22 per cent sugar; bell jar no. 3, 0.66 per cent sugar. The effect of reducing the oxygen supply on the accumulation of sugar in potatoes is, therefore, quite marked, though not nearly so notable as that of low temperature.

II

The view is very generally held that sugar accumulates in potatoes at the time of germination and that this accumulation is essential thereto. According to de Vries* sugar begins to appear in potatoes just prior to germination but before the buds show any signs of growth. Resting potatoes, he says, contain for the most part no sugar, its appearance indicating the initial stages of germination. The sugar first appears in the neighborhood of the eyes, more precisely in the parenchymatous tissue surrounding the bundles leading to them. At first present in small amounts, it soon increases in quantity, developing in all parts of the tubers. During their early period of growth the shoots contain starch but no sugar, though the tubers themselves are full of the latter, the larger amount being in the medulla, the smaller in the cortex. When the shoots are 8 mm. long sugar is found in them only in isolated spots, but somewhat later it is generally distributed, and this condition remains unchanged until they come through the soil.

The accumulation of sugar in potatoes has not, however, as regards germination, any particular physiological significance. As in the case of resting potatoes the amount of sugar found in

* Vries, H. de. Keimungsgeschichte der Kartoffelknollen. Landw. Jahrb. 7: 236. 1878.

germinating tubers is greatly influenced by the milieu in which germination takes place. Potatoes germinating at a relatively low temperature contain more sugar than potatoes germinating at relatively high temperatures, and potatoes germinating in soil contain more sugar than those germinating in a cellar. Again, the distribution of sugar in potatoes germinating in a cellar, for instance, is irregular. All these facts clearly indicate that the metabolism of germination is not concerned primarily in the distribution or degree of accumulation of sugar.* I will give a few examples in illustration.

Conditions favorable for germination are not necessarily favorable for the accumulation of sugar. For instance, on the 26th of April, 1912, I examined a number of Early Ohio potatoes, and they contained as a rule no sugar (PLATE 2, FIG. 6) though the sprouts were replete with it. A sample of these potatoes was placed in the ice compartment of an ice chest for 20 days, after which the potatoes composing it contained sugar as indicated in FIG. 2, 5. At the same time similar potatoes from the cellar contained sugar as indicated in FIG. 1 and 4. It is worthy of note that the potatoes stored in the ice chamber (FIG. 2, 5) resembled very closely the potatoes shown in FIG. 7, as regards distribution of the accumulated sugar. The distribution of sugar illustrated by FIG. 7 was rather common in stored potatoes during March, 1911, which stored potatoes had been at no time subjected to a temperature below 6° C. It is therefore clear that the low temperature had not induced irregularities in metabolism.

A glance at the plate will also force upon one the conclusion that the degree of germination has no effect upon the distribution of sugar. Neither is there any connection between presence or absence of sugar in the cortex with corresponding changes in the medulla. The medulla may contain sugar even in large amounts and the cortex give no reaction for it (FIG. 3, 7); again the cortex may contain sugar and the medulla be free from it (FIG. 1), though such cases appear to be rarer than the former; again the cortex

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* The distribution of sugar in potatoes can be followed by boiling thin slices of the tubers in Fehling's solution for a few minutes, when traces of sugar will be indicated by a yellow coloration and an abundance by a red coloration, various shades of orange indicating intermediate amounts.

may contain sugar in large amounts near the suber and be almost free from it near the line of the medulla, which in turn may be more or less replete with it. Conditions illustrated in FIG. 2, 5, 9 are also not uncommon.

The distribution of sugar in germinating potatoes, considered with reference to the budding eyes, is also worthy of note. If one cuts longitudinal slices through potatoes in which the apical buds alone have sprouted he will find almost invariably that there is less sugar in the tubers immediately below the shoots than elsewhere. The conditions illustrated in FIG. 2, 5, 7, in which the medulla colors orange in Fehling's solution except for small areas beneath the insertion of the shoots and around the buds, may be also observed.

Qualitative tests having indicated that in germinating potatoes sugar occurred in less amounts near the apices than toward the bases and having also given indications that the bases were usually richer than the middle portions, I thought it would be well to have these results confirmed by quantitative analyses. The results obtained were as follows.

TABLE IV

DISTRIBUTION OF SUGAR IN GERMINATING POTATOES

Variety	Percentage reducing sugar in potatoes			Remarks
	Apical zone	Middle zone	Basal zone	
Early Ohio	0.12	.28	.59	Single tuber.
Early Ohio	None	.15	.42	Composite sample of 10 tubers.
Early Ohio	Trace	.35	.88	Single tuber.
Early Ohio	Trace	.46	.50	Single tuber.
Early Ohio	None	.35	.85	Single tuber.
Early Ohio	0.17	.59	.77	Single tuber.

TABLE IV confirms entirely the conclusions deducible from qualitative tests. Potatoes contain little or no sugar near their apices, sometimes nearly as much in their middle as in their basal portions, and sometimes much more towards the base than in the middle. It may be observed that Müller-Thurgau* found that resting potatoes were richer in sugar at the base than at the apex, and we have seen that this is generally true also of germinating potatoes.

* *Loc. cit.* p. 763.

The buds in potatoes tend to be more numerous around the apices, and one would expect, therefore, that during the rest period as well as at germination metabolic activity would be greater in the apical portions. One of the consequences of this increased activity in the apices of the resting potatoes would be a lesser accumulation of sugar and the difference in the percentage present, as one proceeded towards the base, would be the more noticeable, the less ready the translocation of the sugar from one part of the tubers to another: from the seats of lesser activity to the seat of greater activity. The data given in TABLE IV as well as the qualitative results illustrated in PLATE 2 show rather definitely, it seems to me, that there is little if any translocation from remote to budding parts even in germinating potatoes. Were the translocation of sugar a normal and necessary function in the metabolism of germination, its distribution would be more regular and constant; one would find a definite relation existing between cause and effect. The distribution of sugar (when present) in germinating and resting potatoes is not essentially different,* and it would seem, therefore, that its appearance in quantity just before or at germination should be ascribed, at least in part, to metabolic changes induced by another agent, or other agencies.

DURHAM, NEW HAMPSHIRE.

Description of plate 2

FIG. 1. Longitudinal section through Early Ohio from cellar, 16th May 1912.

FIG. 2. Longitudinal section through Early Ohio stored in ice chest 20 days, 16th May 1912. Compare with FIG. 1.

FIG. 3. Longitudinal section through Rural New Yorker from cellar, March 1911.

FIG. 4. Longitudinal section through Early Ohio from cellar, 16th May 1912.

FIG. 5. Longitudinal section through Early Ohio stored in ice chest 20 days, 16th May 1912. Compare with FIG. 1.

FIG. 6. Longitudinal section of Early Ohio from cellar, 26th April 1912.

FIG. 7. Longitudinal section of Early Ohio from cellar, 8th March 1911.

FIG. 8. Longitudinal section through Triumph from cellar, March 1911.

FIG. 9. Longitudinal section through Triumph from cellar, March 1911.

* It is well to point out that germinating potatoes as well as resting potatoes may contain no sugar (cf. FIG. 6).

Studies in the Agalinanae, a subtribe of the Rhinanthaceae *

FRANCIS W. PENNELL

I. NOMENCLATURE OF THE NEARCTIC GENERA

As here defined the Agalinanae constitute a subtribe of the Buchnereae and include a group of closely allied genera, distinguished from *Buchnera* and its nearer allies only by the normally developed two-celled anthers. These studies concern but a section of this group, all American save for one doubtful record from Madagascar, the genera listed by Von Wettstein in Die Natürlichen Pflanzenfamilien as *Esterhazya* Mikan, *Macranthera* Torr., *Seymeria* Pursh, *Silvia* Benth., and *Gerardia* Linn.

In this paper it is desired to place on a firm basis the nomenclature of the genera occurring in North America north of the Mexican Boundary. This has not proved as easy as anticipated, owing to a misunderstanding of a number of older genera, chief among which is that of *Gerardia* itself.

This paper divides itself naturally into two portions, a history of the genus *Gerardia* (Plumier) Linn., explaining the reason for its rejection as a genus of the Rhinanthaceae, and a history of the Rhinanthaceous genera proposed from time to time under which our species of this group must now be placed. This paper concludes with a summary of the nomenclature it is proposed to follow in these studies.

In 1703 the French traveller and botanist, Charles Plumier, a member of the religious order of the Minimi, published a work, "Nova Plantarum Americanarum Genera," containing descriptions of new genera observed during three voyages to America from 1689 to 1697. One of these is the new genus *Gerardia*.

In this work, a volume of 52 pages of Latin text and 40 plates, I find little mention of the portions of America visited, but in the preface to the same author's "Description des Plantes de L'Amérique" more information is given. He tells us that he went

*Contribution from the Botanical Laboratory of the University of Pennsylvania.

first as aid to M. Surian, charged with a commission from the King of France to the Isles Antilles, "to make search of all that Nature there produces most rare and most curious." During the nearly ten years spent in the West Indies, he described, he says, nearly six hundred different plants.

Gerardia is both described and figured. The description reads:—"Gerardia est plantae genus flore A monopetalo, personato, cujus labium superius surrectum est, subrotundum & emarginatum, inferius vero in tres partes divisum, media bifida. Ex calyce autem C surgit pistillum posticae floris parti B, ad instar clavi infixum, quod deinde abit in fructum D oblongum, gibbum, septo medio E, in duo loculamenta divisum, seminibusque foetum orbicularibus F." Then follows the note,—"Gerardiae unicam speciem vidi. Gerardia humilis, Bugulae foliis, Asphodeli radice."

The genus so founded by Plumier remained unaltered, and very little known, till the first edition of the Species Plantarum in 1753. Here Linnaeus took it up, and to Plumier's species which he named *Gerardia tuberosa*, added four others, *purpurea*, *flava*, *pedicularia* and *glutinosa*. It is evident, being the species adopted by Linnaeus from the original author of the genus, incidentally also being his first species listed, *Gerardia tuberosa* L. must be considered the type of the genus *Gerardia* (Plumier) Linnaeus.*

In addition to the striking feature indicated by the specific name, *tuberosa* is characterized by Linnaeus as "Gerardia foliis subovatis tomentosis repandis, longitudine caulis," points quite at variance from those of his other species with which the name *Gerardia* has come later to be exclusively associated. Yet Linnaeus' list of species, including *tuberosa*, with a few additions from time to time, was copied successively from author to author—by Buc'hoz (1778), Lamarck (1786), J. F. Gmelin (1791), etc., to Willdenow (1800), and Persoon (1807). A few authors of this period realized the incongruity of such treatment, and that logically the name *Gerardia* should apply to *tuberosa* alone.

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* Though worked out independently by the writer, this same conclusion was reached a few months earlier by Dr. N. L. Britton. I am indebted to Dr. J. H. Barnhart for reviewing and confirming my determination of the type of *Gerardia*.

First among these was evidently Walter. In his Flora Caroliniana (1788) so far as our North American species are concerned, he relegates *Gerardia* to synonymy, and, not wishing to coin a new name, places *purpurea*, *flava* and *pedicularia* in one of his numerous genera called *Anonymos*.

In 1810 in treating *Gerardia* in Rees' Cyclopedia Sir James E. Smith, after listing first Linnaeus' *tuberosa*, remarks upon its identity being yet doubtful and suggests as a desideratum an examination of its fruit. Then he makes this statement. "Whatever might be the result of such examination this plant must be the true though it were the only *Gerardia*, and the rest in that case must have a new generic appellation and character." This is the first definite assignment of a type species for the genus.

As to the further history of *Gerardia tuberosa* L., after Sir J. E. Smith I find no writer retaining this plant in the Rhinanthaceae. In 1825 Sprengel interpreted it as a synonym of *Ruellia rupestris* Swartz, an Acanthaceous plant, whence in 1847 it was carried into the new genus *Stenandrium* of Nees, becoming a synonym of *Stenandrium rupestre* (Swartz) Nees. If this identification be correct *Stenandrium* Nees should become *Gerardia* (Plumier) L. Though antedating the erection of *Stenandrium* into a genus, such a change was actually made by Rafinesque in his Flora Telluriana in 1838, where *Gerardia tuberosa* L., *G. rupestris* (Swartz) Raf., and *G. scabrosa* (Swartz) Raf. are cited.

In 1835 Bentham in his "Synopsis of the Gerardieae" discusses the past history quite fully, definitely relegates *G. tuberosa* L. to the Acanthaceae, and endorses the earlier selection, practically made by Sprengel, of *G. purpurea* L. as the type. This view has been mostly followed till the present day.

If *Gerardia* is properly an Acanthaceous genus what name is to be applied to our familiar North American species commonly so called?

Of the Linnaean species of this genus to be retained in the Rhinanthaceae three were North American and one Chinese, the latter however not proving a near ally of the others. Species continued to be added from both hemispheres till as late as 1846 when in DeCandolle's Prodromus Bentham finally separated the

series into a number of definitely restricted New World and Old World genera. The Old World genera differ from the New in more points than were realized at that time, so may be definitely dismissed from the present discussion.

After Linnaeus' time the first new names proposed were in 1788 Walter's two genera both named *Anonymos*. These were well characterized; the one might be typified by *Gerardia purpurea* L., the other by a new species *Anonymos cassioides* Walt. Of course the name—or confession of the lack of a name—*Anonymos*, has no value in nomenclature.

In 1791 J. F. Gmelin, reviewing Walter's work, returned his first *Anonymos* to *Gerardia*, but maintained his second *Anonymos* as a new genus *Afzelia*. *Anonymos cassioides* Walt. became *Afzelia cassioides* (Walt.) J. F. Gmel. This genus also was by later authors returned to *Gerardia*, and when in 1814 Pursh became convinced of its generic distinctness, finding the name *Afzelia* meantime applied to a genus of the Caesalpiniaceae, he renamed the genus *Seymeria*. *Afzelia* J. F. Gmel. was restored by Kuntze in 1891. The genus to which this name is applied is a definite, natural group of Mexico and the southern coastal plain region of the United States.

The next generic description in this group is in 1794 that of *Virgularia* described by Ruiz and Pavon from Peru, and based upon their *V. lanceolata*, the specific description of which did not appear till 1798. Though loath with limited material to enter upon any discussion of the South American species of this group, it is necessary to attempt to decide whether this genus can be distinguished from those later proposed to include our North American species.

In the differential characters pointed out by Ruiz and Pavon I find, I confess, little that is convincing. The description of a bifid stigma is surely remarkable, but as no later observer has recorded such a structure in this or in any other South American species of this group, there is doubtless here some error. Also the characters depended upon by Martius (1829) have been shown by Bentham (1835) to be untrustworthy. Since 1835 the name *Virgularia* has been considered a synonym of *Gerardia* L. Yet an inspection of the species of *Virgularia* will, I think, show us

sufficient points of contrast. The material before me is all Bolivian,* but may be safely assigned to this genus.

In *Virgularia* the plant is shrubby, and for our purpose is best distinguished by its tubular, fleshy corolla, mostly red (or some allied shade), after flowering somewhat persistent, shriveling and only tardily falling. These characters appear again, at least in greater part, in the Brazilian *Esterhazya* Mikan, and in our North American *Macranthera* Torr. (to be mentioned later), and seem to indicate a sharp distinction between these three genera and the remainder. *Virgularia* is to be held as a natural, well-marked genus of western South America.

The remainder of this paper will deal strictly with the species of the United States, no other generic name having been proposed from Tropical or South America which can affect the nomenclature of our species. Yet it must be remembered that *a* or *the* great center of this group lies in South America, and no complete understanding of the inter-relationship of the whole can be gained till the species there are studied. Such study is deferred.

The next name that could concern us is in a work descriptive of fruits, *Chytra* Gaertn. fil., 1805. As only the fruit is shown, and that does not seem conclusive—and as no native country whatever is given—this plant may be left permanently as unidentifiable. Such a solution is suggested by Gaertner's specific name *anomala*. Yet it must be recognized that his figure shows a decided resemblance to a "Gerardia" capsule.

In 1819 Rafinesque descrided a yellow-flowered, coarse, lanceolate-leaved plant from Western Kentucky, under a new genus, *Dasistoma*. His description is clear and good, and leaves no doubt that his plant was the one described one year previously (1818) as *Seymeria macrophylla* Nutt. Rafinesque speaks of a short corolla-tube, rotate, 5-lobed limb, 4 nearly equa stamens, short filaments, glabrous anthers, short, cylindrical style, thick, obtuse stigma,—excellent diagnostic characters for *macrophylla*, but all impossible for *Dasistoma* (spelled *Dasystoma*) as taken up in 1846 by Bentham, and followed in later works. *Dasistoma* was based upon *D. aurea* Raf. (1819), antedated by *Seymeria macrophylla* Nutt. (1818), so the combination becomes

* *Bang 188, 730, 2530, 2854; Buchtien 129, 789; Rusby 1077, 1078, 1080, 1081.*

D. macrophylla (Nutt.) Raf. (1837). *Seymeria macrophylla* Nutt. was in 1846 made the basis of a section Brachygyne Benth., which in 1903 was raised to a genus *Brachygyne* (Benth.) Small, identical with the older *Dasistoma* Raf. The genus is monotypic.

In 1834 Nuttall described a new genus *Conradia* based upon a large and showy plant, specimens of which he had seen in the herbarium of the Philadelphia Academy of Natural Sciences. His name *Conradia* was antedated by *Conradia* Raf. (1825), and by *Conradia* Mart. (1829), so in 1835, in the account of the plants of Drummond's collection, the name was changed to *Macranthera.* Though this series of articles in the Companion to the Botanical Magazine was mostly the work of the editor, Sir W. J. Hooker, Bentham is to be credited for this genus. In the original description Le Conte's and Bentham's names were both cited after the genus, but in a later article during the same year Bentham tells us *Macranthera* was a manuscript name used by Dr. Torrey in communicating the plant to Dr. Lindley. Doubtless because the collector of the plant in Torrey's herbarium (however described two years later as a second species) Le Conte was mentioned, so with Bentham's explanation Torrey's name may be connected with the plant in question. *Conradia* Nutt. was based upon *C. fuschioides* Nutt., the spelling of which was corrected to *fuchsioides* in the combination *Macranthera fuchsioides* (Nutt.) Benth. However, as this plant had been previously described by William Bartram in his Travels (1791) as *Gerardia flammea*, this species must become **Macranthera flammea** (Bartram) Pennell comb. nov.

In 1835 Bentham reviewed this tribe, adding no new generic names, but systematizing and coördinating the whole, and with another revision in 1846 giving the outline which has been mostly adopted since.

In 1837 Rafinesque undertook the special elaboration of this group in his New Flora of America, adding several new generic names, not giving us a very satisfactory or coördinated treatment, yet showing nevertheless a surprising insight into the group. As I have already had to refer to several of his names, as he proposed a number of genera which must be adopted, and as since his time no new genera have been proposed which he had not already defined, it will be well to go carefully over his treatment.

In the first place, as already recounted, he definitely carried out Sir J. E. Smith's suggestion, and transferred *Gerardia* as a valid genus to the Acanthaceae.

Our Rhinanthaceous species, *Gerardia* of authors and its near allies, he placed in about eight genera, two of which, *Macranthera* "Torr." Benth. and *Seymeria* Pursh, were adopted from other authors, and one, *Dasistoma*, was, as shown above, an earlier genus of his own.

His first genus was *Aureolaria*, created to include the large, perennial, broad-leaved species, and based upon the current interpretation of *Gerardia flava* L. As his *Dasistoma* has been wrongly applied to this group, this first name becomes the correct one for these plants. As *Gerardia flava* L., both by description and the specimen in the Linnaean herbarium, is synonymous with *Rhinanthus virginicus* L., the type-species of the present genus—our pubescent eastern plant—must be known by the name here given it, *Aureolaria villosa* Raf.

His second genus, doubtfully considered distinct from the last, is nearly as uncertain to the present reviewer. *Panctenis* was based upon *Gerardia pedicularia* L. This species and a few close allies agree with *Aureolaria* in broad leaves, yellow flowers, and awned anthers, but their points of disagreement are equally striking. The annual habit of *Panctenis*, its corolla pubescent without, its wingless seeds, constitute several points of difference. I prefer to treat it as a subgenus of *Aureolaria*. The combination *Aureolaria pedicularia* (L.) was made as a variant by Rafinesque.

His third genus, *Agalinis*, in point of numbers is the most important of all. Based upon *Agalinis palustris* Raf., this genus was designed to include all the slender, narrow-leaved, purple-flowered plants, which Bentham later (1846) has treated as his section Eugerardia, and recent writers have come to consider true *Gerardia*. This is a large genus of both North and South America, falling into a number of well-marked subgenera. The type of the genus, *Agalinis palustris* Raf., is the prevalent plant of moist ground, near marshes, from New England to Carolina, Rafinesque correctly interpreting *Gerardia purpurea* L. as intended to include all the purple species. However *G. purpurea* L. is to be typified by the only Linnaean citation with a figure, Plukenet's "Digitalis

virginiana rubra, foliis et facie antirrhini vulgaris," which is unquestionably the current interpretation of the species. *Agalinis palustris* Raf. becomes **Agalinis purpurea** (L.) Pennell comb. nov.

In *Tomanthera* he placed, as *T. lanceolata*, a plant in his herbarium collected in New Jersey by Dr. Cleaver, and cited the species as occurring in Pennsylvania and Carolina. His plant appears to have been undoubtedly *Gerardia auriculata* Michx., described in 1803 from the prairies of Illinois, his specimen being quite small for the species. Possibly the leaves were abnormally entire, or perhaps they were lobed at base and this feature overlooked. His notice of the rarity of the plant is interesting, agreeing with Dr. Darlington and more recent observers of its sporadic occurrence in the East. With *T. lanceolata* he correctly but doubtfully associated *Gerardia auriculata* Michx., though incorrectly as a distinct species. The genus *Tomanthera*, including two species as now understood, is accordingly based upon *T. auriculata* (Michx.) Raf. In 1835 Bentham had based his section Otophylla upon *Gerardia auriculata* Michx., in 1846 raising this to a genus of the same name. *Otophylla* Benth. (1846) therefore becomes a synonym of *Tomanthera* Raf. (1837).

His *Dasistoma* of 1819 was here continued, and, as above shown, *Seymeria macrophylla* Nutt. was identified with it, though as a distinct species. The name *Dasistoma* was here spelled *Dasistema*, and *D. aurea* of 1819 was changed to *D. auriculata*.

Seymeria he adopted unaltered from Pursh.

A genus *Ovostima* was described based upon one species *O. petiolata* from Florida or Alabama. From the description of the plant, the large smooth corolla, bicuspidate anthers, etc., I believe the plant to have been an *Aureolaria*, though the description of the flower as white is surprising. In *Aureolaria* the corolla is fleshy and blackens in drying, not thin and apparently white or very pale ochroleucous as described for *Ovostima*. The plant is left as of doubtful identity.

Macranthera was adopted from Bentham, and for the two species that had then been published, *M. fuchsioides* (Nutt.) Benth. and *M. Leconteï* Torr., he proposed two additional generic names, *Toxopus* and *Tomilix*. As *M. Leconteï* Torr. appears not to have been published till 1837 there is sufficient evidence that

the date on the title page, 1836, is not the date of this volume of Rafinesque's work. *Macranthera fuchsioides* (Nutt.) was yet again described by Rafinesque as *Russelia flammea* based upon Bartram's incidental description of the plant in his Travels as *Gerardia flammea*, and the suggestion made that it is possibly to be considered as a new genus *Flamaria*.

An earlier genus of Rafinesque's, *Pagesia* (1817), reproduced in the New Flora, has been attributed by various authors to *Dasystoma* or *Gerardia*, but certainly does not belong here. Can *Pagesia leucantha* Raf. be identified with *Mecardonia acuminata* (Walt.) Small?

Finally the genus *Dasanthera* Raf., under which in the New Flora he placed *Gerardia cuneifolia* Pursh and *G. fruticosa* Pursh, has no close affinity with this group, nor even harmony within itself. One species, *G. cuneifolia*, had been already identified by Bentham (1835) as *Gratiola acuminata* Walt. (cited as Ell.), so by synonomy would be *Mecardonia acuminata* (Walt.) Small; the other, *G. fruticosa*, by the same author in 1835 was considered a *Pentstemon*, in 1846 as his *P. Lewisii*, a name which Greene (1892) has changed to *P. fruticosus* (Pursh).

Since 1836 there have been but two new generic names proposed for Nearctic species of this group, *Otophylla* Benth. (1846), and *Brachygyne* (Benth.) Small (1903), both of which are antedated by names of Rafinesque's. The present writer has none to add to the sufficient number already published.

A summary of the Nearctic genera of this group, with the type species for each, would be:

AFZELIA J. F. Gmel.; Linn. Syst. Nat. ed. 13. 927. 1791.
—*Anonymos cassioides* Walt.

—*Seymeria* Pursh, Fl. Amer. Sept. 736. 1814.
—*Anonymos cassioides* Walt.

DASISTOMA Raf. Journ. de Phys. 89: 99. 1819.
—*Dasistoma aurea* Raf. (= *Seymeria macrophylla* Nutt.).

—*Brachygyne* (Benth.) Small, Fl. S. E. U. S. 1073. 1903.
—*Seymeria macrophylla* Nutt.

MACRANTHERA "Torr."; Benth. in Hook. Comp. Bot. Mag. 1: 174. 1835.

—*Conradia fuchsioides* Nutt. (= *Gerardia flammea* Bartram).

—*Conradia* Nutt. Jour. Acad. Nat. Sci. Phila. **7**: 88. 1834 [not *Conradia* Raf. Neog. 3. 1825; nor *Conradia* Mart. Nov. Gen. et Sp. **3**: 38. 1829].

—*Conradia fuchsioides* Nutt.

—*Flamaria* Raf. New Flor. Amer. **2**: 71. 1837.

—*Gerardia flammea* Bartram.

—*Toxopus* Raf. New Flor. Amer. **2**: 71. 1837.

—*Macranthera Lecontei* Torr.

—*Tomilix* Raf. New Flor. Amer. **2**: 72. 1837.

—*Conradia fuchsioides* Nutt.

AUREOLARIA Raf. New Flor. Amer. **2**: 58. 1837.

—*Aureolaria villosa* Raf.

—*Panctenis* Raf. New Flor. Amer. **2**: 60. 1837.

—*Gerardia pedicularia* L.

(?)—*Ovostima* Raf. New Flor. Amer. **2**: 70. 1837.

—*Ovostima petiolata* Raf.

AGALINIS Raf. New Flor. Amer. **2**: 61. 1837.

—*Agalinis palustris* Raf. (= *Gerardia purpurea* L.).

TOMANTHERA Raf. New Flor. Amer. **2**: 65. 1837.

—*Tomanthera lanceolata* Raf. (= *Gerardia auriculata* Michx.).

—*Otophylla* Benth. in DC. Prodr. **10**: 512. 1846.

—*Gerardia auriculata* Michx.

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* I am indebted to Dr. J. H. Barnhart for the date of this volume.

† No date with paper, cited as 1837 in Index Kewensis.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1911–1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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O. BUTLER, PINX.

A. HOEN & CO. LITH.

BUTLER: SIGNIFICANCE OF SUGAR IN POTATOES

Vol. 40 No. 4

BULLETIN

OF THE

TORREY BOTANICAL CLUB

APRIL 1913

Studies in the cytology of the Hymenomycetes, especially the Boleti

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(WITH PLATES 4–8)

The discovery of sexual cell fusions in the rusts has given a great impetus to the investigation of the origin of the binucleated cells in the Basidiomycetes. It made clear that cell fusions without immediate nuclear fusions are possible and may result in an undoubted sporophyte with binucleated cells. An added importance is also given to the study of the nuclear divisions in the basidium as the stage at which chromosome reduction takes place.

Since the appearance of Brefeld's familiar observations on the origin of the carpophore of *Coprinus stercorarius*, it may be regarded as established that no specialized sex organs are necessary for the initiation of the development which leads to the formation of basidia. Brefeld (1876–77) grew the mycelium of this fungus from spores on dung decoction and described and figured two methods of carpophore formation without finding any structures visibly differentiated as sexual organs. He found that the carpophore might have its origin in a single mycelial thread or from a sclerotium, depending on the condition of the culture medium. Brefeld's results seemed for a time to settle the question as to the existence of any form of sexuality in the Basidiomycetes. The question as to the significance of the hyphal fusions in the mycelium, however, still remained open. Two types of fusions between hyphae in the Basidiomycetes have been long known,

[The BULLETIN for March 1913 (**40**: 97–136. *pl. 2*) was issued April 7.]

first the so-called clamp connections and second, the ordinary hyphal anastomoses. Such fusions are, however, well known in other groups of fungi with normal sexual reproduction and the possibility that they may have sexual significance in the Basidiomycetes seems remote.

Hoffman (1856) was the first to figure the clamp connections between hyphal cells. He clearly described the slender tube joining two adjacent cells just outside their common cross wall and gave the name "Schnallenzellen" or clamp connections to these delicate structures. Brefeld emphasized the fact that clamp connections are not permanently open, for shortly after the tube buds out, a wall appears cutting it off from the cell from which it arose. Eventually, he claims, a second wall is formed separating the clamps entirely from each of the cells which it joins. The cell which puts out the clamp connection is always the one on the apical side of the transverse wall. Harper (1902) does not agree with Brefeld on the point that the fusion tube is cut off from both cells which it joins and interprets the clamps as a means of interchange of food stuffs.

Lyman (1907) finds clamp connections arising very early. In one species, *Corticium roseo-pallens*, clamp connections are found in the germ tubes, while in *Corticium subgiganteum* no clamps at all are produced. Lyman studied artificial cultures of 75 species of Thelephoraceae, Hydnaceae, and Polyporaceae and finds accessory reproductive bodies, such as oidia in *Daedalea unicolor*, *Lenzites betulina*, *Polyporus fumosus*, *Polystictus conchifer*, *Polystictus versicolor*, and in *Corticium alutaceum;* and chlamydospores in *Lentodium squamulosum*, *Poria incrustans*, *Radulum tomentosum*, two species of *Hydnum* and one of *Phlebia*, *Corticium vagum*, *C. effuscatum*, and *Michenera artocreas*. Bulbils composed of a mass of hyphae were found in cultures of *Corticium alutaceum*. It would be extremely interesting, in view of the early origin of binucleated cells in the mycelium of many species, to know the number of nuclei in each of these types of asexual spores as an indication of whether they are to be reckoned with the gametophyte or sporophyte generation.

It has been the common view that clamp connections and hyphal anastomoses have to do with food transportation etc.

R. Hartig (1885) however believed that such cell unions resemble a sexual act and he compared these phenomena with the fusions in the Conjugatae. He traced the development of *Merulius lacrymans* from spore to spore and describes hyphal anastomoses and clamp connections as common in its mycelium and crustlike carpophore. Meyer (1896–1902) describes the formation of hyphal anastomoses in *Hypomyces rosellus*. He states that when one hyphal cell comes in contact with another a fusion may take place. The walls at the point of contact disappear and the protoplasm of the two unite. Soon afterward a new wall is formed which only incompletely separates the two cells. Meyer believes that the fusions of hyphae by anastomoses, involving the fusion of plasms not closely related, may have the same effect as cytoplasmic fusion in a normal fertilization. In view of the well established fusions found in the rusts, Voss' claim (1903) that clamp connections and hyphal anastomoses are also present in this group has considerable interest. His observations, so far however, have not been confirmed.

Ordinary pit connections for the transfer of food materials are undoubtedly present in the cross walls of the hyphae of all the higher fungi. Strasburger, 1884, maintains for *Agaricus campestris*, that the cells in the stipe show so-called protoplasmic continuity.

Miss Wakefield's (1909) observations on the conditions governing the production of the carpophore in *Schizophyllum commune* and *Stereum purpureum* are quite in harmony with the view that the origin of the carpophore in the Hymenomycetes is in no way associated with a sexual act. She finds that the production of carpophores depends upon the rate of transpiration. Thus carpophores are produced when transpiration is slow while none are formed when evaporation is too rapid.

The determination of the number of nuclei in the hyphal cells and the more exact study of their behavior has led to quite new conceptions as to the presence of sex in the Basidiomycetes. De Bary (1866) first observed the nucleus of the basidium in *Corticium amorphum*. Strasburger (1884) using alcohol and alum haematoxylin was able to demonstrate, beyond a doubt, that there are nuclei in the hyphal cells of *Psalliota campestris* and in

the basidium of *Russula rubra*, and Rosenvinge (1887) extended this conclusion to thirty-five species of Basidiomycetes. Rosen (1892) working on material from *Lepiota mucida* first observed nuclear fusions in the basidium. He concluded, however, that the secondary nucleus of the basidium resulted from the fusion of six or eight nuclei coming from the hyphae of the lamellae.

Wager (1893–'4–'9) gave us the basis for most of our present day conceptions of the nuclear phenomena in the basidium. He followed Rosen in the conception that more than two nuclei may fuse in the formation of the secondary nucleus of the basidium (see table, p. 164). He even suggests the probability of a number of nuclear fusions occurring before the primary nuclei pass into the basidium. Wager observed that in the fusion of the nuclei their chromatic reticula become intermingled and that the nucleoles finally fuse. He describes the nuclei of the basidium as having the typical structures found in higher plants, such as, chromatin, linin, differentially stained nucleoles, nuclear membranes, etc.; and was able to make out karyokinetic division figures. How the spindle is formed Wager could not make out, but believes that it comes in some fashion from an archoplasmic body. The chromosomes are six to eight in number.

Dangeard (1895) was the first to establish the fact that only two nuclei fuse to form the secondary nucleus in the basidium of *Tremella mesenterica*, *Dacryomyces deliquescens*, *Calocera viscosa*, *Craterellus sinuosus*, *Bovista plumbea*, *Nyctalis parasitica*, *Hydnum repandum*, and *Polyporus versicolor*. He was the first also to affirm the sexual nature of this nuclear fusion in the basidium as well as in the ascus, the teleutospore, and the spore of the smuts. On these facts he bases his well-known doctrine that the Ustilagineae, Uredineae, Basidiomycetes, and Ascomycetes have a sexuality which is essentially equivalent to that of the higher animals and plants. Dangeard claims that the young ascus, the young basidium, the teleutospore, and the smut spore are oögones and develop in one of the following ways. In the first case, the egg germinates by producing a promycelial outgrowth which produces sporidia endogenously as in the ascus, or exogenously as on the promycelium of the teleutospore and smut spore. In the second case the egg becomes segmented into a number of

parts, by transverse or vertical walls, as in the Protobasidiomycetes. In the last case the egg neither divides nor becomes elongated but produces sporidia on sterigmata.

In *Tremella Genistae*, *Dacryomyces chrysocomus*, *D. deliquescens*, and *Polyporus annosus*, Istvanffi (1895) claims that there is no nuclear fusion in the basidium. He further observed that there are two generations of spores formed on the basidia of *Dacryomyces chrysocomus* and *D. deliquescens*. On this point he has been confirmed by both Juel and Maire, while Dangeard holds that in these forms the secondary nucleus divides only once and only one generation of spores is formed. Istvanffi also describes the formation of two generations of spores from the basidia of *Hydnangium carneum*. He also found uninucleated oidia and chlamydospores in *Nyctalis asterophora*, *Psathyra spadiceo-grisea*, *Stropharia melasperma*, *Galera tenera*, and *Collybia tuberosa*, which would suggest the existence of a fairly long gametophytic stage, which is capable of reproducing itself asexually in these forms. In *Merulius fugax* he finds that the mycelium is not septate.

Juel (1898) points out that Brefeld's distinction between Protobasidiomycetes and Autobasidiomycetes is supported by cytological evidence since the long axis of the primary spindle is either regularly parallel or perpendicular to the long axis of the basidium in the two groups. My own observations as described below do not show any such constancy in the position of the spindle in the basidium of the Boleti. Juel finds from six to eight chromosomes, which vary in size, in the basidia of *Auricularia mesenterica*, and *Exidia truncata*.

Maire (1902), while he emphasizes the existence of an alternation of generations in the Basidiomycetes, makes no contribution to the solution of the question as to the point of origin of the sporophyte. He claims that the cells of the stipe and pileus become multinucleated (table, p. 164) by amitotic division. He found, however, that the young mycelium of *Coprinus radiatus* has uninucleated, cells and produces uninucleated oidia. He shows clearly that the nuclear fusion in the basidium is not a true fecundation and proposes to call it a "mixie," pointing out that the morphological equivalent of sexual cell fusion must come at the origin of the binucleated condition.

The basidium is a spore mother cell and not an egg and the nuclear fusion in it is associated with the phenomena of chromosome reduction. Maire describes and figures a synapsis stage in the prophases of the first division and gives good figures of centrosomes, polar asters, etc., in a number of forms. In *Sclerodermа vulgare* he found a deeply staining granule on the wall of the resting nucleus, which he believes to be a centrosome. As to the number of chromosomes, Maire is plainly in error. His figures showing two chromosomes are due to poor fixations and the true chromosomes are undoubtedly shown in his protochromosomes. He first observed the appearance of cytoplasmic threads connecting the nuclei and the sterigmata at the four-nucleated stage of the basidia. He believes that the nuclei move into the sterigmata by the contraction of the threads and thus finally reach the spore. Maire observed this process of nuclear migration in several agarics, a boletus, and a puff ball.

Maire also discovered the interesting and as yet unexplained abnormalities of the basidia of *Hygrophorus conicus* and *H. ceraceus*. Their subhymenial cells and young basidia are uninucleated. The nucleus in the basidium, which is bisterigmatic, divides, forming two nuclei which migrate into the spores. Occasionally one of the nuclei in the basidium divides before entering the spore, in this case the two nuclei migrate to one spore while the undivided nucleus goes to the other spore where it divides. In *Clavaria rugosa* and *Cantharellus cinereus* he observed as many as three divisions of the secondary nucleus. In the latter species a variable number of spores are formed, from one to five, irrespective of the number of nuclei.

The observations of Wager, Juel, and Maire, as to the appearance of the spindles, astral rays, centrosomes, etc., were confirmed in the main by Ruhland (1901). He describes the nuclear phenomena in a number of Basidiomycetes (see table, p. 164). He denies that four spores are ever formed on the basidium of *Hydnangium carneum*, although the phenomena leading up to the four-nucleated stage are quite regular. He claims that either one or two spores may be formed. When two spores are formed two nuclei pass into each. In case only one spore is formed all four nuclei migrate into it.

Strands connecting nuclei and sterigmata have been observed also by Petri (1902) and Van Bambeke (1903). Petri holds that these fibers are extensions of the nuclear membranes. He counts five to six chromosomes in the first division; Van Bambeke agrees with Maire as to the number of chromosomes in the Basidiomycetes. Harper (1902) shows the presence of six to eight chromosomes on the spindle of *Hypochnus subtilis*. In this species he found all the cells of the thin filmy subhymenial layer binucleated.

Miss Nichols (1904) finds binucleated cells in the rhizomorphs of *Hypholoma perplexum*, *Crepidotus*, *Corticium lilacino-fuscum*, *Dictyophora duplicata*, *Poria*, *Pholiota praecox*, *Lepiota naucina* and *Lycoperdon pyriforme*, and holds that there is in *Hypholoma perplexum* an uninterrupted series of binucleated cells from the rhizomorphs through the stipe, pileus, trama, and subhymenium to the basidium. The germ tubes from spores of this fungus and *Coprinus ephemerus*, grown in pure culture, are commonly multinucleated; although binucleated cells were found in the mycelia of *Coprinus ephemerus* twenty-four hours old.

Fries (1911[1]) figures and describes synapsis, longitudinal splitting of the spirem, spindles with centrosomes and astral rays in the basidium of *Nidularia pisiformis*. He holds that on the primary spindle six to eight chromosomes can be seen. In the second division the chromosomes in the equatorial plate are four in number while the number seen at the poles is but two. He observed also the strands connecting the nuclei and sterigmata and describes granules which he associates with centrosomes, on the walls of the basidium at the points where the sterigmata are to appear. Fries (1911[2]) also confirms *in toto* Maire's observations on the nuclear phenomena in *Hygrophorus conicus* and holds that only one nucleus is found in the subhymenial cell and young basidium. Kniep (1911) grew the mycelium of *Armillaria mellea* from spores in a gelatin medium, and reports that its mycelial cells are uninucleated throughout. He figures basidia formed directly from this uninucleated mycelium without the development of a carpophore. Whether the bodies Kniep figures as basidia are really these organs seems doubtful.

Recent investigators have devoted much attention to the

nature and function of the cystidium, and Buller and Knoll have ascribed to them hitherto unsuspected functions. Buller (1910) as a result of elaborate studies concluded that the cystidia of the Coprini act as props and emphasizes the importance of the interlamellar spaces for the dispersal of the spores. In *Inocybe asterophora* Buller describes the cystidia as excreting a mucilaginous substance. Patouillard (1887), Massee (1887, 1894, 1904, 1906), Istvanffi (1896), Topin (1901), Maire (1910), and Demelius (1911, 1912) hold that the cystidia are organs of excretion or are in some way related to the functions of excretion. Maire (1910) holds with Topin (1901) that the function of the cystidium varies with the stage of its development. In its young stage the cystidium is a storage organ of reserve food for the hymenium. Ultimately the cystidium becomes an excretory organ. Massee (1887) holds that the cystidia of the gill-bearing fungi are the terminal cells of laticiferous vessels. Their contents escape through a nipple-like filiform attentuation at the apex of the cystidium. Miss Demelius (1911, 1912) is of the opinion that the cystidia serve to protect the fungus from the invasion of insects. She emphasizes their variability in form, as in *Collybia radicata*, which has spherical, spindle-shaped and finger-like cystidia upon which excretion products may or may not appear.

Knoll (1912) endeavors to prove that the cystidia are one-celled hydathodes comparable to the active water-excreting cells in the epidermis of the phanerogams. He maintains that trichom-hydathodes, as he calls them, are also found on all parts of the carpophore as well as in the hymenium. They are definitely shaped cells having a slender foot and a much expanded middle region while the upper part forms a sort of neck. The excretion forms a spherical drop at the apex. The fluid excreted contains a jelly which remains after the water has evaporated. Besides water, Knoll believes that the cystidia excrete by-products of metabolism and so accounts for the appearance of crystals of calcium oxalate on their tops. He also holds that the hydathodes may have a protective function in the case of fungi with exposed hymenial surfaces. For Knoll, the cystidia of the Coprini are aberrant types whose true function remains obscure.

MATERIALS AND METHODS

Spores of *Pholiota praecox* and numerous Boleti were collected by placing the pilei on circular sheets of filter paper and covering the whole with a bell jar. The spore prints were kept in sterilized Petri dishes. Miss Ferguson's (1902) method of collecting spores was also used. The Petri dishes with the spore prints were kept in an ordinary refrigerator until needed. A great number of culture media were tried; among those which gave the best results were string beans, and fresh horse manure prepared in a manner similar to that described by Duggar (1901). Cherry agar was prepared by boiling 250 gms. of fresh cherries in a liter of water. The cherries on becoming soft were strained through a cheese cloth and the skins, pits, and stalks were discarded. The juice of the cherries was again boiled with 15–20 gms. of agar agar and the decoction was then filtered and sterilized in an autoclave. Malt-beef agar was made by adding 25 gms. of Loeflund's malt and 25 gms. of Liebig's beef extract to a liter of water. This was then mixed with 15–20 gms. of dissolved agar agar and boiled and neutralized with n/1000 NaOH. The solution was then filtered and sterilized.

The spores germinated best in the malt-beef medium. In the case of *Pholiota praecox* 65 per cent of the spores germinated in this medium. Cherry and malt-beef agars were used for the propagation of the mycelia of several Polypores. The cultures were kept in dark boxes at temperatures varying from 23°–30° C. The early stages of spore germination from cultures in Van Tieghem's cells were killed and fixed to slides by a modification of Harper's (1899) and Lutman's (1910) methods. The cover glass on which the culture is grown is removed from the ring and a few drops of the fixing solution are added. The cover glass with the culture is then inverted over slides covered with a film of albumen fixative and gently tapped till part of the drop falls on it. The spores in the drop become fixed to the slide by the coagulation of the albumen. The slide is then set aside till the liquid partly evaporates. The preparation is hardened by pouring graded alcohol over it, and it is then ready for staining. More fixing solution may be added to the culture drop and the process repeated till all the spores have been removed. A minimum of disturbance of the delicate germ tubes is achieved by this method.

Older mycelia of *Pholiota praecox* were obtained by sowing the spores in Petri dishes partly filled with bean, cherry, or malt agar. These were kept in the dark. After three days sufficient growth results to make the fungus visible to the naked eye. The cultures were then transferred to test tubes, from which subsequent cultures were made.

Mycelia of *Polyporus adustus*, *P. betulinus*, *P. destructor*, *P. versicolor*, *Collybia velutipes*, and *Coniophora cerebella* were obtained in pure culture from the Association Internationale des Botanistes. These were propagated by transferring small pieces (2–5 mm. sq.) of the mycelium to Petri dishes with malt-beef, cherry, and bean agars. To secure perfect penetration of the fixative in the case of mycelia, the method described by Miss Nichols (1904) was used.

Most of my material was collected in the vicinity of New York City. A number of Boleti were also sent to me from Woods Hole. In all, the carpophores of twenty-four species of Boleti and three species of Polypores were studied. Of these *Boletus granulatus*, *B. castaneus*, *B. albellus*, *B. versipellis*, *B. vermiculosus*, *B. glabellus*, *B. chrysenteron*, *B. indecisus*, and *B. pallidus* were the more favorable for cytological work on the mature carpophore. I have not succeeded in germinating the spores of any of the Boleti.

Flemming's weaker solutions gave the best results, although Merkel's, Juel's, and Bouin's gave fair fixations. Flemming's triple stain was used. Heidenhain's iron haematoxylin also gave favorable results.

To Prof. R. A. Harper, on whose advice this work was undertaken, I wish to extend many thanks for his kind suggestions and criticisms.

SPORE GERMINATION AND MYCELIA

As noted above, the question as to the origin of the binucleated cells in the higher Basidiomycetes remains still unsettled. I find that the spores of *Pholiota praecox* germinate readily and I have studied the germ tubes and young mycelium with reference to this question. Spores from spore prints, obtained in the manner described above, were sown in Van Tieghem's cells with bean, malt-beef, and dung decoctions.

Within six hours, 20 to 30 per cent of the spores will germinate, and in general, there seem to be only slight differences between cultures kept in the dark and those exposed to the light. At the end of twenty-four hours, however, 60 to 70 per cent of the spores had germinated in malt-beef decoctions while only 40 to 50 per cent had germinated in dung decoction. The spores of *Pholiota praecox* in germinating do not swell or burst but push out a dense globular bud at the apical end, opposite the point of attachment. Germinating spores, at intervals ranging from six to twelve hours, were transferred from the Van Tieghem cells to slides by the modified stippling method, described above. They were then stained with Flemming's triple stain. The globular bud that first appears from the germinating spore is very dense and at first contains no nuclei. It grows rapidly into an ordinary germ tube and a nucleus appears in it, which is soon followed by another. I have not seen nuclear division figures at this stage, but soon two, four, and more nuclei can be found in the germ tube lying near the spore. In cultures fifteen hours old (PL. 4, FIG. 1) the germ tubes have branched and a large number of nuclei are present. The main germ tube is an outgrowth of the initial globular bud which is more or less permanent, and is still visible in older cultures. The cytoplasm shows a reticulated structure with larger and more or less numerous vacuoles. The nuclei are irregularly distributed through the cytoplasm and show no definitely paired arrangement. Few if any cross walls have been formed at this stage and the hyphal cells are beyond question multinucleated. The nuclei are very small, yet each one shows a distinct nuclear membrane, and a red staining nucleole, while the chromatin is granular and stains a faint blue. In the further growth of the hyphae up to the forty-eight hour stage, new branches are formed from the bulbous initial bud near the spore, as well as from the main germ tube. Septa are still scarce in these stages; none are shown in FIG. 2, PL. 4. The diameter of the nuclei is nearly equal to that of the hypha.

The lateral branches generally show several nuclei which are similar in all respects to those in the main germ tube. The cytoplasm is denser near the apical portion of the branches and fewer vacuoles appear in this region. The cells up to the forty-eight hour stage are all multinucleated.

Malt-beef agar cultures sixty-eight hours old were imbedded in paraffin and sectioned. The cultures were made directly by sowing spores in Petri dishes or the spores were allowed to germinate from twelve to twenty-four hours in the Van Tieghem cells and were then transferred to Petri dishes. Both methods gave satisfactory results. The mycelium reaches a diameter of a centimeter on the surface of the agar within three days. Entire masses of mycelium of this size, together with the agar, were cut out and immersed in fixing solutions so as to disturb the hyphae as little as possible. The hardening with alcohols must be very carefully done. If dehydration is too rapid, the agar shrivels. Considerable difficulty is encountered in staining such sections since the agar as well as the fungus takes the stain. In using the triple stain very short exposures and dilution of the orange G are necessary. Sections of material three days old show both binucleated and uninucleated cells making up the mycelium. Long multinucleated cells are also found, which are the germ tubes of spores that germinate late. Cultures of the same age do not all of course show the same stage of development. The cytoplasm (PL. 4, FIG. 3, 4) is less dense in these hyphae and stains better. The vacuoles are large and extend across the entire width of the cells. The structure of the nuclei in the uninucleated cells appears very clearly (PL. 4, FIG. 3). The chromatin is composed of delicate strands distributed irregularly through the nuclear cavity. The nuclei of the binucleated cells as shown in FIG. 4, PL. 4, are smaller but show the same structure as those in the uninucleated cells. In cultures three days old, clamp connections and hyphal anastomoses were first noticed. Lyman (1907) reports for *Corticium roseopallens* that clamp connections may be found on germ tubes immediately after spore germination. Cultures, from spores sown in Petri dishes in malt-beef agar seven days old, make a layer of mycelium covering the entire surface of the agar. The mycelium from such cultures shows considerable numbers of multinucleated cells. Their cytoplasm is dense, the vacuoles are small and they resemble the multinucleated cells in the younger cultures described. Binucleated cells similar to those observed in cultures three days old appear more frequently and uninucleated cells are also observed occasionally. The latter are long and their cytoplasm shows large

vacuoles. Clamp connections may be seen at one or both ends of the cells and are very common. At this stage small concavo-convex bodies on both sides of the cross walls of the hyphae appear. These structures stain red with safranin and are dense, homogeneous bodies. They have been interpreted by Strasburger (1884), Harper (1902), and others as indicating the presence of protoplasmic connections between the adjacent cells. Hyphal anastomoses, such as are described by R. Hartig (1885) and Meyer (1896, 1902), are also present.

For comparison, I have also studied the mycelium of *Collybia velutipes*, which grows rapidly in malt-beef and cherry agar. Miss Cool (1912) and Biffen (1899) have both studied its mycelium. I find that the cells of the mycelium are distinctly binucleated. Narrower hyphae densely filled with cytoplasm were also found in sections of this mycelium. The terminal portion of these filaments becomes divided into uninucleated cells which give rise to cylindrical uninucleated oidia similar to those described by Biffen for the same species and Miss Nichols (1904) for *Coprinus ephemerus*. Clamp connections are regularly present and in thick sections hyphal anastomoses can be also found.

The results thus obtained show in the germ tube and early stages of mycelial growth that multinucleated cells predominate in *Pholiota praecox*, while in cultures two to three days old, multinucleated, binucleated and uninucleated cells are all present. The multinucleated cells may belong to younger hyphae as noted. In older cultures binucleated cells mainly prevail although multinucleated and uninucleated cells may be found. The origin of the binucleated condition is not clear, but it is very apparent that it appears early in the vegetative hyphae and persists throughout the subsequent development of the mycelium and the carpophore.

The cells of the mature mycelium of *Collybia velutipes* are all binucleated and here the binucleated condition may be regarded as fixed for the entire subsequent development, except as in the case of the stipe or the pileus, where the nuclei may divide, forming multinucleated cells.

Cultures of four species of Polypores obtained from the Association Internationale des Botanistes were also studied. The

species were *Polyporus adustus*, *P. betulinus*, *P. destructor*, and *P. versicolor*. The first two and the last were also studied by Miss Cool (1912). The material was propagated by transferring small pieces (2–5 mm. sq.) of the mycelia from each culture to a variety of agar media. Soft malt-beef and cherry agars proved the most favorable. Parts of such mycelia were fixed in Flemming's, Juel's, Bouin's, and Hermann's solutions but the most favorable results were obtained with Flemming's weaker solutions. Clamp connections are of course abundantly present in the cells of these mycelia. I did not specially study the development of the clamps, but it is plain that the mature clamp is not cut off from the two cells which it joins, as Brefeld (1877) held for *Coprinus stercorarius*. Only one cross wall is formed separating the clamp from the cell from which it arose. In well stained preparations hemispherical pads similar to those described above are visible on both sides of this cross wall in the clamp. This perhaps indicates only a partial closing up of the opening originally present. Similar pads may be seen also on the septa between many of the hyphal cells (PL. 4, FIG. 8). Hyphal anastomoses in these mycelia are also common. The hyphae of these Polypores (PL. 5, FIG. 5, 6) are made up of a series of regularly binucleated cells.

In the mycelium of *Polyporus versicolor* (PL. 4, FIG. 8) undoubted uninucleated cells are also present but they are not common; the mycelia in cultures of *P. destructor* and *P. betulinus* (PL. 4, FIG. 7) may show non-nucleated cells which are joined to adjacent binucleated cells by hyphal anastomoses and clamps.

I have also studied the cells of *Coniophora cerebella*, also obtained from the Association Internationale des Botanistes. They are regularly binucleated; clamps and hyphal anastomoses are also present.

It is plain that the binucleated condition is fixed in all these forms long before they proceed to the formation of a carpophore.

My mycelial cultures all showed on their surfaces the familiar appearance of droplets of water, varying in size from small globules 0.5 mm. in diameter, to large ones 10 mm. in diameter. The small drops are countless while the large ones are relatively few. Regarding Knoll's (1912) contention that many of the Basidiomycetes are provided with sp cial hair-like organs, trichome-hyda-

thodes, for the excretion of water, I may note that my microscopic sections of mycelia in the region where the water appears showed no such specialized organs for its excretion. I found no differentiated structure that could be possibly associated with such a function and I am of the opinion that all the mycelial cells can excrete water.

CARPOPHORE AND BASIDIA OF THE BOLETI

The carpophores of the Boleti because of their soft fleshy consistency and rapid growth are more favorable for cytological study than the pilei of the Polypores. An abundance of material of the common *Boletus granulatus* collected in the fall of 1911 proved favorable for fixing and staining. A large number of other forms were also studied for comparison. Pieces of the stipe, pileus, ring,* and pores were fixed with Flemming's weaker solutions and Merkel's mixture. Flemming's triple stain was used almost exclusively although a number of preparations were stained with Heidenhain's iron haematoxylin.

Longitudinal sections of all parts of the stipe, at, above, and below the ring show it is composed of an undifferentiated mass of interwoven hyphae. The hyphal cells toward the center of an old stipe are more loosely interwoven as compared with those near the periphery and form what Ruhland has appropriately called a plectenchyma. The cells vary in diameter and present an appearance in cross section similar to that figured by Harper (1902) for *Coprinus ephemerus*, although the difference in diameter is not quite so great. The cross walls show the so-called protoplasmic connections as figured by Strasburger (1884). Clamp connections on hyphal anastomoses are entirely lacking. Many cells in the plectenchyma are binucleated; the majority, however, are multinucleated. The distribution of these cells is not regular although there is a tendency for the cells in the center of the stipe to become multinucleated early. According to Maire this multinucleated condition is the result of an amitotic division of the two original nuclei in the cell, though no one has conclusively proved

* The presence or absence of a ring is the generally accepted means of separating *Boletus luteus* and *B. granulatus*. In my material, both annulate and exannulate forms, otherwise indistinguishable, were collected at the same time and place,

the presence of such divisions. The cytoplasm in the cells of the stipe contains very large vacuoles. The nuclei are comparatively (PL. 4, FIG. 9) large and have typically red-stained nucleoles and blue chromatin. In very old stipes the comet-shaped nuclei figured by Ruhland also appear. The cell walls of the cells in the ring are mucilaginous and these cells may branch. They are regularly binucleated (PL. 4, FIG. 10).

The upper surface of the semiglobular pileus of *B. granulatus* is covered by a viscid layer of slime. The flesh is thick; the pores are relatively short. Small cushion-like glandular bodies are conspicuous about their mouths.

The flesh of the pileus is made up of a meshwork of intertwining hyphae with numerous air spaces. The cortical cells of the cap are similar to those in the interior, but their walls are gelatinous. In very old material the mucilaginous layer is very thick and surrounds almost all of the cells down to the pores. The cells of the flesh are short and are almost invariably binucleated (PL. 5, FIG. 11). I have found however a few cases of cells with from three to four nuclei.

In old material of *B. granulatus* the trama, the subhymenium, and the hymenium are very distinctly differentiated. The trama is composed of bundles of long parallel hyphae. The straightest filaments are found in the center, while toward the periphery they become more interwoven. The terminal branches of the hyphae of the trama may be traced directly into the subhymenium as is well shown in *B. vermiculosus*, *B. glabellus*, and *B. pallidus*. The cell walls are thick and gelatinous, and take a blue color with the triple stain. Gelatinous material may also fill the intercellular spaces. Two nuclei are found in every cell. Frequently in the nuclei of the ring (PL. 4, FIG. 10), flesh, and trama a darkly staining granule is found on the nuclear membrane, to which the chromatin of the nuclei seems to be attached. The position of this body varies; it is sometimes found lying opposite the nucleole but frequently it is near it. This body resembles the central body described by Harper (1905), for the mycelial nuclei of the mildews. The subhymenial cells are short and are binucleated. Their cell walls do not become gelatinous, and their cross walls as also those of the trama and flesh show the characteristic hemispherical pads

described above. The basidium mother cells in *B. granulatus* are formed as in all other cases by the division of the subhymenial cells. I have not been able to find nuclear or cell division figures at this stage. The mother cell divides and the outer cell of the two may become either a cystidium or a basidium. Occasionally the last nuclear division is not followed by a cell division in the basidium mother cell of *B. granulatus*. A four-nucleated cell results (PL. 6, FIG. 45), which elongates and resembles a basidium. It is however decidedly different in appearance from the four nucleated basidium found in later stages. It is slender, more deeply seated in the hymenium and the nuclei are arranged serially. The subsequent behavior of such cells was not determined.

Paraphyses have been described as elements of the hymenium since the latter part of the 18th century. According to Léveillé (1837) the term was first used by Montagne to signify a sterile basidium, but in more recent years the function of "space maker" has been attributed to them by de Bary (1887), Brefeld (1877), Fayod (1889) and Buller (1910). It seems to me that in all cases the paraphyses are really immature basidia; as is held also by Miss Demelius, who believes that some of them, at least, are, as she describes them, "derzeit nicht fertile Basidien." In the Boleti a number of basidia in similarly advanced stages are frequently found developing in close contact with each other.

The cystidia of the Boleti appear either singly or in clusters. Such clustered cystidia are not uncommon, for Patouillard (1887), Demelius (1912), and Knoll (1912) have also found them. In *B. granulatus* such clusters are covered by a gelatinous excretion and are visible, as noted above, as minute dark specks about the mouths of the pores and over the surface of the hymenium. The individual cystidium is club-shaped; the entire cluster (PL. 7, FIG. 12) forms a cushion-shaped mass. Cystidia in all stages of development may be found in a single cluster. FIG. 12 "a," PL. 7, shows very young cystidia which are approximately the size of the mature basidia. FIG. 12 "b," 12 "c," PL. 7, represent later stages of their development. The young cystidium (PL. 5, FIG. 13) shows a dense granular cytoplasm, which is somewhat fibrillar in the upper part of the cell; vacuoles are also present. The young cystidium is regularly binucleated; the nuclei are in all essentials similar to those found in the basidium.

The subhymenial cell from which the cystidium arises is proportionately larger and may be frequently traced back into a long filament of binucleated cells in the trama (PL. 5, FIG. 15). The cell wall is slightly thickened (PL. 6, FIG. 14) and is entirely covered by the mucilaginous material referred to above. The evidence is clear that the cystidia, in *B. granulatus* at least, are glandular structures. The two nuclei are small in proportion to the volume of the cell but the nucleo-cytoplasmic equilibrium is not disturbed since the increase in the size of the cell is apparently due to an increase in the metaplasmic substances which form the source of the material that the cell excretes. The mucilaginous mass stains a faint orange with the triple stain. The outer surface of the gelatinous mass becomes dense and dark in color and ultimately forms a thin pellicle over the entire gland (PL. 7, FIG. 12). The formation of mucilage does not take place through any specialized pore as Massee (1887, 1904) holds, nor is it associated with any localized region of the cystidium as Maire (1910) and Knoll (1912) contend, but apparently takes place over the entire surface of the cystidial cell. Later the cystidium begins to disintegrate. Its cytoplasm shows large vacuoles. The nuclei also begin to show signs of disintegration. The nuclear membrane becomes faint, the nucleoles and chromatin lose their affinity for stains and soon disappear. Subsequent stages show the cell wall shriveled and the nuclei and cytoplasm entirely gone. Single flask-shaped cystidia (PL. 8, FIG. 60) are found in all the species of the Boleti I have studied except *B. granulatus*. Their nuclei and cytoplasm are essentially similar to those of *B. granulatus*. Tubular cystidia are found in *B. vermiculosus*, *B. albellus*, and *B. scaber*. They are long cylindrical binucleated cells filled with a granular cytoplasm similar to that described for *B. granulatus*.

The nuclei of the basidia of the Boleti I have studied are quite favorable for cytological study. The chromatin strands stain blue and the nucleoles a bright ruby red, with the triple stain. The nucleoles have about the same size relative to that of the whole nucleus as they have in the higher plants. The cytoplasm of the young basidium (PL. 8, FIG. 46) is finely vacuolar and stains a faint orange. With the growth of the basidium the nuclei (PL. 6, FIG. 16, 17) also increase in size. At the time of fusion their di-

ameter is several times that of the nuclei in the subhymenium. The fusion stages are abundant and easily studied. The chromatin in the nuclei before fusion loses its reticulated structure and a number of strands appear (PL. 5, FIG. 70). The nuclei in fusing become appressed upon each other and the nuclear membranes disappear in the region of contact. We have thus a two-lobed stage (PL. 6, FIG. 18) which lasts for some time, showing that the surface tension does not operate to round out instantly the united masses of the fusing pair, as might be the case if they were merely vacuoles. The nuclear membranes, however, form a continuous boundary (PL. 8, FIG. 47, 48) for the combined nuclear cavities and the constriction in the plane of fusion gradually disappears. The method of union of the chromatin masses is not easy to make out. The strands soon become mingled so as to be indistinguishable as to their origin.

I am inclined to believe, however, that the union is nothing more than the approximation of the chromatin strands bringing them into close contact with each other side by side (PL. 8, FIG. 46). At any rate the chromatin masses from the primary nuclei become so intermingled as to leave no visible evidence of their two-fold origin at this stage. The nucleoles approach, come in contact with each other, and eventually fuse (PL. 8, FIG. 49), forming a proportionately larger mass.

The basidium continues to grow and larger vacuoles appear in its cytoplasm. The secondary nucleus lies in the center of the basidium and goes through a resting period. At this stage I have also observed a dense oval body which stains red, lying in various positions in the basidia of *Boletus granulatus*, *B. albellus*, *B. versipellis*, *B. indecisus*, and *Strobilomyces strobilaceus*. In *B. albellus*, this body is sometimes found in the upper part of the basidium. Radiating from it are long strands of kinoplasm. In this species (PL. 7, FIG. 61) and in *B. granulatus* I have also found a similar structure lying between the basidium wall and the nucleus. In *B. versipellis* the body lies near the nucleus and resembles more or less the archoplasmic masses figured by Wager (1894) for *Mycena galericulata*. I have not been able to connect this body with the processes of nuclear division and I have no proof that, as Wager holds, it is the origin of the centrosomes and karyokinetic figures.

The first division usually takes place in the upper part of the basidium, although the prophase stages begin while the nucleus is still near its center. The chromatin strands combine to form a long slender thread which forms a more or less irregular coil filling the nuclear cavity. The chromatin filament may become quite thick and thus resemble a post-synaptic spirem (PL. 6, FIG. 19, 20; PL. 7, FIG. 71; PL. 8, FIG. 50). I also found a parallelism of the spirem strands which suggests splitting (PL. 6, FIG. 21). My figures of these stages show a close resemblance to those of Fries (1911[1]) for *Nidularia pisiformis*. The spirem now becomes segmented as shown in FIG. 22, PL. 6, and each segment soon becomes shorter and denser. The number of these chromatic segments apparently varies and it is very difficult to count them. During nuclear division a large vacuole appears at the base of the basidium. The nucleus moves toward the apex of the basidium and the spindle figure appears. The nuclear membrane disintegrates and the chromosomes are found lying in a faintly blue-stained fibrillar spindle whose axis is transverse to the longitudinal axis of the basidium (PL. 6, FIG. 23). The nucleole is found in the cytoplasm (PL. 8, FIG. 52, 53). In some of my preparations the nuclear membrane and nucleole seem to have disappeared before or soon after the spindle is formed, while in others both are present at the equatorial plate stage (PL. 8, FIG. 51). The direction of the long axis of the spindle in the division of the primary nucleus in the Boleti does not always conform to the generally accepted view as emphasized by Juel (1897) and others. I found that while the transverse position is common there are many cases in which the primary spindle may be very decidedly inclined, at least seventy degrees to the transverse axis of the basidium (PL. 7, FIG. 62). I have observed such cases in *Boletus granulatus*, *B. chrysenteron*, *B. badius*, *B. alutarius*. and *B. albellus*. The poles of the spindle end in small red-stained centrosomes from which long streaming rays extend to the center of the basidium (PL. 8, FIG. 51, 53). The appearance of the polar asters agrees well with that shown by Maire (1902) for *B. regius*. The cones of astral rays as seen in section resemble diminutive comet tails. The degree to which the rays are developed depends upon the position of the pole in the basidium. If the pole lies on the wall few or no rays are visible.

Compare the astral rays in FIG. 72, 73, PL. 6 and FIG. 51, 53, PL. 8, with those shown in FIG. 24, 62, PL. 7 and FIG. 58, PL. 8. Well-developed polar asters are shown in my preparations of *Boletus castaneus*, *B. glabellus*, *B. vermiculosus*, *B. versipellis*, *B. chrysenteron*, *B. punctipes*, *B. griseus*, *B. subtomentosus*, and *B. cyanescens*.

The number of chromosomes is difficult to determine but in favorable sections I have been able to count from six to eight. They lie as shown by Wager (1894), Ruhland (1901), Juel (1897), Harper (1902) and others in the center of the spindle although no characteristically dense equatorial plate is formed (PL. 6, FIG. 72, 73).

The chromosomes are drawn to the poles and at the same time the spindle elongates until its ends (PL. 6, FIG. 25; PL. 8, FIG. 54, 55) touch the basidium wall. Astral rays may be still seen radiating in all directions from the point of contact. The chromosomes become densely aggregated at the poles. I have been able, however, to see distinctly, in perfect fixations, as many as five chromosomes just before they reached the poles (PL. 6, FIG. 25a). Undoubtedly the appearance of two chromosomes in the equatorial plate and diaster stages, as reported by Maire (1902) and Van Bambeke (1903), indicates fusion of the chromosomes due to imperfect fixations.

In the reconstruction of the daughter nuclei, a nuclear membrane is formed about the chromosomes. The latter begin to stream out (PL. 6, FIG. 26) forming a reticulated structure, and small nucleoles appear. The resulting nuclei resemble in all respects the mother nuclei. In FIG. 56, PL. 8, the two daughter nuclei are shown attached to the basidium wall. Faint astral rays are still visible coming from the point of contact. The old nucleole may be seen lying in the cytoplasm. This persistence of the kinoplasmic rays is conspicuous, but they disappear before the second spindle is formed. The two daughter nuclei prepare immediately for the second division. The prophases are hard to study. I have observed in *Boletus versipellis*, that the nucleoles come to lie on the side of the nucleus toward the base of the basidium (PL. 8, FIG. 57) and pass out into the cytoplasm, after the disintegration of the nuclear membrane. The spindles show centrosomes with

long astral rays. I find that in *B. versipellis* also (PL. 8, FIG. 58) the two secondary spindles may be at an angle of about 10° to the longitudinal axis of the basidium. In these division figures, considerable variation is found in the angle formed by a transverse axis of the basidium and the long axis of the spindle.

The nuclear membranes still persist at the equatorial plate stage (PL. 8, FIG. 59). In a polar view of the equatorial plate at least four distinct chromosomes can be seen. In the diaster stage however they are often seen as one or two masses (PL. 6, FIG. 28, 29). I have been able, however, to demonstrate that at the poles also there are more than two chromosomes, as is shown in FIG. 27, PL. 6. The secondary spindles may become elongated until the chromosome masses reach the wall of the basidium as in the first division, suggesting that the kinoplasmic rays are attached to the basidium wall and are pulling the chromosomes and centers to it.

The young daughter nuclei grow rapidly in size (PL. 6, FIG. 30, 31) and remain for some time attached to the basidium wall. They then begin to move downward toward the base of the basidium and it at once becomes evident that they are connected by faintly stained strands with small granules which lie on the upper wall of the basidium at the point from which they started (PL. 5, FIG. 32). The origin of these granules cannot be easily determined. From their size, color reactions, and position in the basidium it appears that they probably may be the centrosomes, which became fixed to the wall of the basidium in the process of division. The position of the centrosomes on the upper part of the basidium wall indicates the position of the future sterigmata.

According to Petri (1902) the strands are the stretched nuclear membranes. I have been able to follow the development of these structures. In the early stages of their movement the nuclei resemble the beaked nuclei (PL. 6, FIG. 33) found in the Ascomycetes during the process of spore formation. As the main body of the nucleus progresses farther from the cell wall the fibrils become longer and thicker and resemble in all respects the strands figured by Maire (1902) and Fries (1911). I believe the fibrillar strand possibly may be analogous to astral rays; though as Petri suggests they may be due to the pulling out of the nuclear membrane.

At this stage I have also found another type of fibrils in the cytoplasm. These latter run irregularly but in the main lengthwise of the basidium. It may be that they are indications of cytoplasmic streaming.

As the sterigmata bud out (PL. 6, FIG. 34, 35, 74) the centrosomes and strands are carried upward; the centrosomes remaining at the apex of the sterigma. In mature sterigmata (PL. 7, FIG. 36, 78) the granule lies at the apex and the nucleus is still attached to it by the fibrillar strands. In this stage of development the four nuclei are found at or below the middle of the basidium (PL. 5, FIG. 37) but do not show any indication of fusing as Wager holds for *Stropharia stercoraria*. A small globular mass of cytoplasm, the spore initial, now appears at the end of each sterigma (PL. 7, FIG. 38). The growth is rapid; later stages are shown in FIG. 39, 40, PL. 7. On the upper, inner surface of the spore wall the centrosome is still visible (PL. 5, FIG. 41) and from it the fibrillar strand passes down through the sterigma to the nucleus in the basidium. It seems that the centrosome marks the apex of growth for the spore as well as for the sterigma. In the spores of *B. castaneus* (PL. 7, FIG. 75) a number of fibrils radiate downward from the centrosome through the cytoplasm but the strand which runs to the nucleus is thicker than the others.

These fibrillar strands connecting the nuclei with the sterigmata and spores are present in practically all the Boleti I have studied. In the basidia of *Merulius tremellosus* I have also observed them extending from the apex of the spores to the nuclei below in the basidium. In *Polyporus brumalis* and *P. lucidus* I could trace them only from the sterigmata to the nuclei.

Simultaneously with the development of the spores the nuclei begin to move towards the sterigmata. This migration is probably the result of the contraction of the kinoplasmic fibrils as claimed by Maire (1902). In FIG. 63, PL. 7, of *Boletus albellus* the nucleus is shown part way through the sterigma. In the same spore higher up another spherical, red staining body appears. Its lower portion is attenuated forming a long, strand-like fibril which extends in the direction of the nucleus. What the nature of this body is I have not been able to determine.

The nucleus (PL. 8, FIG. 64) divides soon after entering the spore

(PL. 5, FIG. 42). I have seen division figures in the spores of *Boletus castaneus*, *B. albellus*, *B. punctipes*, *B. cyanescens*, *B. indecisus*, *B. glabellus*, *B. granulatus*, *B. chrysenteron*, *B. spectabilis*, *B. bicolor*, *B. griseus*, *B. subtomentosus*, *B. badius*, and *Strobilomyces strobilaceus*. The equatorial plate and subsequent stages come out very clearly and well-developed polar asters are present. Long astral rays can be seen radiating from the centers and extending to the ends of the spore (PL. 7, FIG. 79). The spindles are very narrow, but show clearly in the cavity of the nucleus, the nuclear membrane being stillpresent. The chromosomes are sharply differentiated from the spindle fibers (PL. 5, FIG. 76) but are so small and so massed together that their numbers cannot be definitely counted. The position of the spindles is either transverse or parallel to the long axis of the spore. The central spindle stretches in the anaphases and the chromosomes come to lie on the walls on opposite sides of the spore (PL. 8, FIG. 43, 65). The two daughter nuclei show all the essential features of the nuclei in the basidium (PL. 8, FIG. 66). In the spore of *B. albellus*, a second division occurs. The spore (PL. 8, FIG. 67) becomes very long and the two spindles which appear are similar to those previously described. The spindles may lie parallel or at right angles to each other, the latter case is shown in FIG. 68, PL. 8, where one of a pair of spindles is represented. FIG. 67, 68, PL. 8, show clearly that the number of chromosomes is greater than two, as held by Fries (1911[1]) for the first division in the spore.

In the late anaphases, the chromosomes are found at the poles and appear to be fused into one or two masses. The nuclei are reconstructed and four small daughter nuclei result. The division here is not apparently conjugate. The spindles at least are not paired side by side, though the divisions are simultaneous. In many spores, I have found three nuclei (PL. 8, FIG. 69). Two were small, while the third was larger and had probably not yet divided. It seems probable that the condition found in these spores indicates the initial stage in germination.

The karyokinetic figures in the spores of these Boleti are very distinct and suggest that further study of young mycelia will make possible the settlement of the question as to the first appearance of conjugate division and regularly binucleated cells.

Centrosomes and astral rays are strongly and typically developed. Although it is difficult to determine the exact number of chromosomes certainly more than two are found at all stages. In the first division of the basidium where the spindles are large as many as six to eight can be counted.

Aberrant types of basidia have been found in *Boletus chrysenteron*, *B. punctipes*, and *B. griseus*. The abnormality consists in the appearance of mature sterigma-like projections while the nuclei are still in the process of division. FIG. 77, PL. 5, shows a basidium with one of its four sterigmata well developed. The division figures are perfectly normal, with the exception that they are almost perpendicular to the transverse axis of the basidium.

THEORETICAL DISCUSSION

I cannot agree with Knoll that the cystidia in the Basidiomycetes are hydathodes. The cystidia of the Boleti I have studied are evidently modified basidia whose function is in some sense glandular. The quantity of material excreted is very large and in no way resembles the mucilaginous substance found about the trama cells. Just how this substance is excreted by the cystidia is not clear but in all probability it is formed just beneath the cuticle as described by Tschirch (1889) for the gland cells in the higher plants.

As I have pointed out, the excretion products in the form of a gelatinous substance may be usually found covering the entire surface of the cell. In the case of *Boletus granulatus*, where several cystidia are found together, a cushion-like gelatinous mass is formed. These masses are the "granules" (PL. 7, FIG. 12) at the mouths of the pores. Knoll admits that a mucilaginous substance accumulates on the upper part of the cystidia of *Psathyrella gracilis*, *Galera tenera*, *G. tenuissima*, *Peniophora globulosa*, *Paneolus helvolus*, and *Coprinus lagopus* and figures the cystidia of *Collybia esculenta*, *Psathyrella consimilis*, and *Inocybe trechispora* as entirely covered with it. Knoll has done nothing to disprove the contention of Lepeschkin (1906) who showed that the discharge of water from hyphal cells in general depends only upon the condition of the plasma membrane. Biffen (1899) finds that in the case of *Collybia velutipes*, watery drops may be exuded from

any part of the carpophore, particularly the pileus, and notes three different kinds of cells covered by a watery exudation. The well-known occurrence of water drops on mycelial cultures is another fact strongly against the conception of special water-excreting organs in the fungi. As I have pointed out, cytological study of the mycelial cells shows no specially differentiated organs for the excretion of water.

The mechanical function ascribed to the cystidia by Buller for the Coprini is entirely out of the question in the Boleti. The pores need no such aid to keep them open. I have noticed in many species numbers of spores embedded in the mucilaginous covering of the cystidia. It seems that in this case the cystidia rather interfere with the dispersal of the spores than assist in it.

The question as to the method of origin of the binucleated cells and the stage at which they appear in the development of the carpophore is of interest not only with reference to its bearing on the problems of the morphology and phylogeny of the Basidiomycetes but also and even more in its bearing on the whole question of the nature of sexual reproduction. If a sporophyte with cells containing $2n$ chromosomes can arise by the simple omission of a cell division in a binucleated cell and if this process can occur at various points in a mycelium either simultaneously or over quite a period of development the fact is of prime significance in the interpretation of gametic unions of the more typical sort. As noted above, the absence of differentiated sex organs at the initiation of the carpophore must be taken as an established fact, but the possibility perhaps still remains that the binucleated cells have their origin by the migration of nuclei through clamp connections or hyphal anastomoses. Meyer (1896, 1902) and R. Hartig (1885) have argued on general grounds that such cytoplasmic fusions may have some sexual significance. The observations of Lutman (1910) and Rawitscher (1912) that in the smuts the nuclei do migrate through such connecting tubes are certainly suggestive.

Voss' (1902) claim that clamp connections are present in the rusts, if confirmed, must be certainly regarded as good evidence against their function as conjugation tubes, since sexual fusions of another type are present in the rusts. Voss' observations,

however, are not generally accepted, and his figures are inconclusive. My own studies on the nature of the clamps and hyphal fusions are not conclusive, on this point. As described above, I have observed clamp connections and hyphal anastomoses in cultures three days old, but nothing that would clearly indicate nuclear migrations, though in some cases I have found empty cells adjacent to binucleated cells.

It is well established that the binucleated cells do not arise as carpophore initials. They are present long before the carpophores appear and the stimuli leading to the production of the latter seem to be vegetative and environmental.

In order to bring out clearly the stages at which binucleated sporophytic cells are found I have tabulated all the available data as to the number of nuclei in the cells of the mycelia, rhizomorphs, carpophores, etc., of the Basidiomycetes so far studied. Twenty-seven species have been described as having regularly binucleated cells in their mycelia and rhizomorphs. The data show rather clearly that the binucleated condition does not originate at any definite point but may arise anywhere in the mycelium. The germ tubes (PL. 4, FIG. 1, 2) are generally multinucleated. The young mycelium has multinucleated cells (PL. 4, FIG. 3, 4) although binucleated and uninucleated cells are also found. Miss Nichols does not believe that there are conjugate divisions in the germ tube but positive observations as to the occurrence of conjugate divisions are sadly lacking. As noted above, I have found no case of conjugate division in the material I studied.

As shown in the table, oidia and chlamydospores are reported by Istvanffi (1895), Biffen (1899), Maire (1902), and Nichols (1904), for many forms. I have studied such asexual spores on the mycelia of *Collybia velutipes*. The evidence seems to be that these spores are usually uninucleated and it would seem natural that the mycelia from which they arise should consist of uninucleated cells. Such spores are certainly not so common in the Basidiomycetes as they are in the Ascomycetes. They probably should be regarded as the asexual reproductive bodies of a gametophyte stage. As yet no binucleated spores from binucleated hyphal cells like the uredospores of the rusts have been found in the Basidiomycetes.

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	AURICULARIACEAE										
Istvanffi	*Auricularia Auricula-Judae* L.	1 o.									
Sappin-Trouffy	" " "						2	2		2	2
Maire	" *mesenterica* Dicks	1		2						2	2
	TREMELLACEAE										
Juel	*Exidia truncata* Fr.	1								2	
Maire	*Sebacina effusa* Bref.			2						2	
Maire	" *quercina* Vuill.			2							
Maire	*Tremella Genistae* Lib.									2	
Maire	*Vuilleminia comedens* (Nees) R. Maire									2	2
	DACRYOMYCETACEAE										
Maire	*Calocera cornea*	2							2	2	2
Dangeard	" *viscosa*	1		3–4					2	2	2
Dangeard	*Dacryomyces deliquescens*	2 c. 1		2						2	
Istvanffi	" "	1 c.									
Juel	" "	1								2	
Maire	" "	2 o. 1								2	2
Perrot	*Guepinia helvelloides* Fr.									2	2
Maire	" *rufa* (Jacq.) Pat.	1								2	2
	EXOBASIDIACEAE										
Maire	*Exobasidium Andromedae* Karst.	1							2	2	
Maire	*Hypochnus Sambuci* Pers.			2					2	2	
Harper	" *subtilis*	1		2					2	2	

* A number of species were omitted where the author merely reported the number of nuclei in the basidium.

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES.—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	THELEPHORACEAE										
Levine	*Coniophora cerebella*			2							
Nichols	*Corticium lilacino-fuscum*				2						
Maire	" *lacteum* Pers.	1		2					2	2	
Maire	*Craterellus cornucopioides* L.	1							2	2	2
Rosenvinge	" "	2							2	1	
Dangeard	" *sinuosus*	1							2	2	
Maire	*Cyphella ciliata* Saut.					2	2		2	2	
Maire	" *digitalis* A.-E.					2	2		2	2	
Maire	*Dictyolus bryophilus* Pers.	1								2	2
Maire	" *glaucus* Butsch.	1								2	
Maire	*Peniophora quercina* (Pers.) Cooke	1		2						2 cy.	
		1		8					2	2	
Maire	*Thelephora anthocephala* Bull.								2	2	2
Maire	" *palmata* Scop.								2	2	2
	CLAVARIACEAE										
Maire	*Clavaria grisea* Pers.	1								2	2
Maire	" *rugosa* Bull.	1							6–8	2	2
Rosenvinge	" *vermicularis* Scop.	2									1–4
Maire	*Sparassis crispa* Wulf.	1								2	2
	HYDNACEAE										
Dangeard	*Hydnum repandum* L.	1							2	2	
Maire	" "								2	2	
	POLYPORACEAE										
Maire	*Auriculariopsis ampla* (Lév.) R. Maire								2	2	
Maire	*Boletus flavus*	2						2	2	2	

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES.—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	POLYPORACEAE										
Levine*	*Boletus glabellus*	2						2	2	2 cy. 2	
Levine	" *granulatus*	2				∞	2	2	2	2 cy. 2	
Levine	" *pallidus*	2						2	2	2 cy. 2	
Maire	" *regius* Krombh.	2						2	2	2 cy. 2	
Levine	" *vermiculosus*	2						2	2	2 cy. 2	
Levine	" *versipellis*	2						2	2	2 cy. 2	
Istvanffi	*Fistulina hepatica* Huds	1 c.									
Maire	" "	2 c.					2–4	2	2	2	
Maire	*Lenzites flaccida* Fr.						2	2	2	2	
Istvanffi	*Merulius fugax* Fr.			∞							
Maire	" *lacrymans* (Wulf.) Pat.	1		2						2	
Levine	" *tremellosus*								2	2	
Juel	*Muciporus corticola* (Fr.) Juel									2	2
Maire	*Polyporus acanthoides* Bull.						2–∞				
Levine	" *adustus*			2							
Istvanffi	" *annosus*	1 c. 1		∞							
Levine	" *betulinus*			2							
Levine	" *destructor*			2							

* Boleti and Polypores in which I found binucleated spores and binucleated cells in the subhymenium and hymenium are *Boletus albellus*, *B. alutarius*, *B. badius*, *B. bicolor*, *B. castaneus*, *B. chrysenteron*, *B. cyanescens*, *B. felleus*, *B. griseus*, *B. indecisus*, *B. luridus*, *B. ornatipes*, *B. punctipes*, *B. scaber*, *B. spectabilis*, *B. subtomentosus*, *Strobilomyces strobilaceus*, *Polyporus brumalis*, *P. lucidus*, and *Merulius tremellosus*.

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES.—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	POLYPORACEAE										
Dangeard	*Polyporus versicolor* L.								2	2	
Levine	" "			2							
Nichols	*Poria*				2						
	AGARICACEAE										
Wager	*Amanita muscaria* L.	2								2–3	
Maire	" *pantherina* D.C.	2							2	2	
Kniep	*Armillaria mellea*	1		1						1 M.B.	
Ruhland	" "							2	2	2	
Maire	*Camarophyllus virgineus* Wulf							2–∞	2	2	
Maire	*Cantharellus cibarius* L.	1						2	2	2	
Maire	" *cinereus* Pers.	1				2	2		2	2	2
Perrot	" *infundibuliformis*	1								2	
Maire	" *tubaeformis*	1								2	
Perrot	*Clitocybe amethystina* Bolt.	1						2	2	2	2–8
Maire	" *aurantiaca* (Wulf.) Studer	2				2	2	2	2	2	
Maire	*Clitopilus orcella*	1–2					2	2	2	2	
Istvanffi	*Collybia tuberosa* Fr.	1 o.		1							
Maire	" "			2							
Biffen	" *velutipes*	1 o.									
Levine	" "	1 o.		2							
Harper	*Coprinus ephemerus*					8 2		2	2	2	
Nichols	" "	2		8		8	2	2	2	2	
Maire	" *radiatus*	1 o.		1							2
Maire	" *tuberosus* Quél.				2–∞						
Nichols	*Crepidotus*				2		2	2	2	2	
Istvanffi	*Galera tenera* Sch.	1 c.									
Maire	*Gomphidius glutinosus* Sch	1							2	2	

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES.—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	AGARICACEAE										
Maire	*Hygrocybe miniata*	2						2	2	2	
Maire	*Hygrophorus agathosmus*	1						2	2	2	
Maire	" *ceraceus*	2						2–∞	1	1	
Fries	" *conicus*	2							1	1	
Maire	" "	2					2	2–4	1	1	
Maire	" *lucorum* Kalchbr.						2	2 ∞	2	2	
Maire	*Hypholoma appendiculatum* Bull.	1						2	2	2	
Maire	" *fasciculare* Huds.	1						2	2	2	
Nichols	" *perplexum* Pk.	1 o. 2	∞		2	2	2	2	2	2	
Maire	" *sublateritium* Fr.						2	2	2	4 cy. 2	
Maire	*Lactarius deliciosus* L.	2							2	2 cy. 2	
Perrot	" "	1					2			2	
Maire	" *piperatus* L.	1							2	2	
Ruhland	*Lepiota cepaestipes*							2–4		2	
Ruhland	" *lilacino-granulosa* Henn								2	2	2
Rosen	" *mucida* Schr.					∞			2	6–8	
Nichols	" *naucina*			2							
Ruhland	*Marasmius scorodonius* Fr.									4 cy. 2	
Maire	*Mycena galericulata*	2						2	2	2	
Wager	" "					∞			2	4	
Istvanffi	*Nyctalis asterophora* Fr.	1 ch.									
Maire	" " "	2 ch.						2	2	2	
Dangeard	" *parasitica*	2 ch.						2	2	2	
Maire	*Paxillus involutus*	2						2	2	2	
Maire	*Pholiota lucifera*	1							2	2	

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES.—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	AGARICACEAE										
Levine	*Pholiota praecox*		∞	1–2							
Nichols	" "			2							
Maire	*Pluteus cervinus*							∞	∞	2 cy. 2	
Lewis	*Psalliota bisporigera*	1								2	
Maire	" *campestris* L.	4				2–∞		2–∞	2	2	
Rosen	" "									6–8	
Strasburger	" "					∞					
Strasburger	" *pratensis* Sch.					∞					
Istvanffi	*Psathyra spadiceo-grisea*	1–2 0.									
Maire	*Psathyrella crenata* Lasch.			1					2	2	
Maire	" *disseminata*	1				2	2	2	2	2	
Perrot	*Russula integra* L.							2–∞		2	
Maire	" *lepida*	1							2	2 cy. 2	
Strasburger	" *rubra*									1–8	
Istvanffi	*Stropharia melasperma*			1							
Maire	" *semiglobata*	1					∞	∞	2	2	
Wager	" *stercoraria*	2								2	
	PHALLACEAE										
Nichols	*Dictyophora duplicata*			2							
Maire	*Phallus impudicus* L.	2			2–∞				2	2	
	HYMENOGASTRACEAE										
Van Bambeke	*Hydnangium carneum* Wallr.	2–8		1–2					2	2	
Istvanffi	" "	1							2	2	
Petri	" "	4		1–2					2	2	
Ruhland	" "	1–6							2	2	

NUMBER OF NUCLEI IN THE CELLS OF THE BASIDIOMYCETES—*Continued*

Observer	Species	Spore	Germ tube	Mycelium	Rhizomorph	Stipe	Pileus	Trama	Subhymenium	Young basidium	Carpophore
	LYCOPERDACEAE										
Dangeard	*Bovista plumbea* Pers.	2	.....	.....	.....	.....	.....	.....	.....	2	.....
Maire	*Geaster fimbriatus* Fr.	2	.....	.....	.....	.....	.....	.....	2	2	.....
Maire	*Lycoperdon caelatum* Bull.	2	.....	.....	.....	.....	.....	2–∞	2	2	.....
Maire	" *excipuliforme* Scop.	2	.....	.....	.....	.....	.....	.....	2	2	2
Maire	" *gemmatum* Fl. Dan.	2	.....	.....	.....	.....	.....	.....	2	2	.....
Nichols	" *pyriforme*	.....	.....	2	.....	.....	.....	.....	.....	.....	.....
	NIDULARIACEAE										
Maire	*Cyathus hirsutus*	.....	.....	.....	.....	.....	.....	.....	2	2	2
Maire	*Nidularia globosa* Ehr.	2	.....	.....	.....	.....	.....	.....	.....	2	2
Fries	" *pisiformis* Tub.	2	.....	.....	.....	.....	.....	.....	.....	2	2
	SCLERODERMATACEAE										
Maire	*Scleroderma vulgare*	2	.....	.....	.....	.....	.....	.....	2	2	.....

o. = oidia
c. = conidia
ch. = chlamydospores
cy. = cystidia
M.B. = mycelial basidia
∞ = multinucleated

The question as to the possible morphological equivalence of the carpophore of the Basidiomycetes and the ascocarp of the Ascomycetes is a difficult one. The development of the ascocarp is in many cases at least initiated by functional or possibly non-functional sex organs. It is possible that in the apogamous Ascomycetes which have been reported as lacking an ascogone, the ascocarp may arise in the same fashion as does the carpophore in the Basidiomycetes. It is to be noted however that binucleated mycelia are not so far known to occur in these apogamous Ascomycetes.

I am of the opinion that in the Boleti at least none of the cells of the hymenium may be properly regarded as paraphyses. They are all binucleated when young and are all potentially either basidia or cystidia. That certain of these cells serve merely as "space makers" is an interpretation which appears to me to be without much proof. Certainly there are no paraphyses here which can be compared to those in the Ascomycetes. In the latter the paraphyses are typically gametophytic while in the Basidiomycetes all the elements of the hymenium are just as certainly sporophytic.

The constancy in the occurrence of a nuclear fusion followed by a double nuclear division in the basidium is now generally conceded. Uninucleated basidia such as those of *Hygrophorus conicus* reported by Maire (1902) and Fries (1911[2]) are apparently rare exceptions. The young basidia of twenty-four species of Boleti and three species of Polypores which I have examined are all binucleated. The two nuclei fuse in all cases and the resulting nucleus divides twice, forming four nuclei. These four nuclei migrate to the spores and there divide again.

It is an obvious conclusion that these two nuclear divisions in the basidium involve the reduction of the chromosome number but the small size of the nuclei makes it impossible to reach new or independent conclusions as to the nature of the reduction process. Fries (1911[1]) and Kniep (1911) hold that the first and second divisions in the basidium are respectively heterotypic and homoeotypic. But it cannot be said that their figures give any very positive evidence on the large questions here involved. My preparations show clearly (PL. 6, FIG. 27) that the number of chromo-

somes in the second division is certainly greater than two. The number which can be distinguished is variable but more than two are always found. This is true even in the case of the very small karyokinetic figures of the second division in the spore as shown in FIG. 68, PL. 8. That we have a reduction division in the basidium comparable to that found in the spore mother cells of the higher plants is hardly to be questioned on general grounds; but the diminutive size of the chromosomes makes the study of the process extremely difficult. It is certainly clear, however, that Maire's (1902) and Van Bambeke's (1903) two chromosomes in both divisions, and Fries' (1911) two chromosomes in the second division and in the division in the spores are the results of poor fixation causing the fusion of the chromosomes.

My observations on the Boleti confirm the views of Wager (1903, 1904), Juel (1897), and Harper (1902), and it cannot be doubted that Maire's protochromosomes are the true chromosomes.

Maire (1902) and more recently Fries (1911) have given extremely interesting data as to the migration of the four nuclei from the basidium into the spore. The nuclei according to their observations are drawn into the sterigmata by fibrillar cytoplasmic strands which extend from the sterigmata to the nuclei. My preparations show clearly also the kinoplasmic strands extending from the nuclei to the points of origin of the sterigmata (PL. 7, FIG. 36; PL. 5, FIG. 37). Petri held that these strands originate by stretching of the nuclear membrane. The daughter nuclei in the telophases become attached to the basidium and when they move downward in their well-known migration, the nuclear membrane is drawn out into a long fibrillar strand. The strand may be compared to a much attenuated beak on the nucleus. Another interpretation of these strands is possible. As noted in the telophases of the second division, the daughter nuclei come to lie on the wall of the basidium and apparently their positions mark the point of origin for the future sterigmata. When the nuclei migrate downward in the basidium, the centrosomes are left behind on the basidium wall. The sterigma, budding out at just this point, carries the centrosomes upward (PL. 5, FIG. 37), at its apex. The strands connecting the centrosomes and nuclei are thus carried

upward with the growth of the sterigma. This growth of the sterigma naturally involves flowage of material into it and that this movement should express itself in the formation of fibrillar strands between the nucleus and the centrosome at the apex of the sterigma is certainly to be expected and indicates the relation of the nucleus to the metabolic activities of the basidium. The strands on this view would be comparable, in general, to the kinoplasmic astral rays.

My preparations show further that when the spore buds out on the apex of the sterigma the centrosome is carried up at the apex of the growing spore. The fibrillar strands are extended also into the spore and appear running through its long axis and maintaining a continuous connection with the nuclei which now lie at the middle or towards the base of the basidium (PL. 7, FIG. 40, 75; PL. 5, FIG. 41).

It appears to be generally conceded that these strands are associated in some way with the passage of the nuclei into the spore. My observations in the Boleti certainly give good ground for the contention that they at least direct the course of the nuclei into the spores. The fact that, as I find, these strands extend through the sterigma and into and through the spore body, suggests also that they may be of significance for the apparently difficult process of getting the nucleus through the narrow neck of the sterigma.

I find nothing in the Boleti to favor Fries' (1911[1]) claim that the migrating nuclei undergo a characteristic transformation in passing into the spore. It is, perhaps, not entirely proven that these fibrillar strands are actively contractile kinoplasmic elements which pull the nuclei into the spores but the appearances in the Boleti certainly suggest such a conclusion. Such a conception is, of course, not inconsistent with the view that such strands may also constitute a system of lines of flowage of material into the young spore.

SUMMARY

1. Spores of *Pholiota praecox* germinated in malt-beef extract at room temperature produce multinucleated germ tubes. The mycelia in cultures forty-eight hours old are still composed of long multinucleated cells. In cultures three days old both uninucleated and binucleated cells are found.

2. The mycelia of *Collybia velutipes*, *Polyporus adustus*, *P. betulinus*, *P. destructor*, *P. versicolor*, and *Coniophora cerebella* propagated from old cultures are made up of long series of binucleated cells. Clamp connections, hyphal anastomoses, and the so-called protoplasmic connections are numerous in all the mycelia.

3. The cells of the mature stipe of *Boletus granulatus* are all multinucleated, while the cells of the ring are binucleated. The cells of the flesh and trama of *B. granulatus* are binucleated. The cells of the subhymenium are binucleated in all the species of Boletus studied.

4. The cystidia of the Boleti occur either singly or in small clusters forming gelatinous granules. In *B. granulatus* these cushion-shaped "granules" are abundant at the mouths of the pores and scattered over the hymenium. The individual cystidium is binucleated. It is club-shaped and is deeply seated in the hymenium. The cystidia of the Boleti appear to be in some sense glandular in their functions.

5. The nuclear phenomena in the basidium are typical in all the species of Boletus examined. Fusion of the two primary nuclei of the basidium was observed in *Boletus granulatus*, *B. versipellis*, *B. glabellus*, *B. vermiculosus*, *B. castaneus*, *B. albellus*, and *B. chrysenteron*.

6. The long axes of the spindles in both divisions are commonly transverse to the long axis of the basidium. Variations, however, appear in which the spindles are almost perpendicular to the transverse axis of the basidium. Centrosomes and well-developed astral rays are regularly present.

7. The chromosome number in the first division is from six to eight in *Boletus granulatus*, *B. castaneus*, *B. albellus*, *B. vermiculosus*, *B. versipellis*, and *B. chrysenteron*. In the second division the exact number cannot be determined. It is, however, always more than two.

8. At the end of the second division the centrosomes become attached to the walls of the basidium and the four daughter nuclei are reconstructed in close connection with them. As the nuclei move downward in the basidium they maintain their connection with the centrosomes by means of fibrillar strands which are, perhaps, analogous to astral rays. The fibrillar strands apparently pull the nuclei into the spores.

9. The centrosomes mark the points of origin for the sterigmata. They are carried up with the growth of the sterigmata and into the spores. They also apparently determine the apex of growth of the spores.

10. The spores in all the forms studied are uninucleated at first. The primary spore nucleus divides at once. The karyokinetic figures are small but very sharply differentiated with well-developed centrosomes and polar asters. In the spores of *B. albellus* a second division occurs.

11. In *Boletus chrysenteron*, *B. punctipes*, and *B. griseus*, basidia with mature sterigmata are found before the completion of the second division. Normal basidia are also present.

12. An alternation of generations comparable to that in the Uredineae is also present in the Basidiomycetes. The sporophyte begins at some indefinite point in the mycelium and extends through the development of the carpophore.

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All the figures were drawn with the aid of a camera lucida and with the Leitz 1/16 objective. Figs. 11, 14, 16–45 were made with ocular 4; distance from camera mirror to drawing board 260 mm. Figs. 1, 3, 4, 5, 6, 9, 10, 46–79 were made with ocular 4; distance from camera mirror to drawing board 170 mm. Figs. 13, 15 were made with ocular 4; distance from camera mirror to drawing board 90 mm. Fig. 7 was made with ocular 3; distance from camera mirror to drawing board 90 mm. Figs. 2, 8, 12 were made with ocular 1; distance from camera to drawing board 90 mm.

Explanation of plates 4–8

PLATE 4

Pholiota praecox.

FIG. 1. Germination tube at the end of fifteen and a half hours.

FIG. 2. Same as Fig. 1 at end of forty-eight hours.

FIG. 3. Uninucleated hyphal cells in mycelium three days old.

FIG. 4. Binucleated hyphal cells in mycelium three days old.

Polyporus betulinus.

FIG. 7. Binucleated hyphal cells from old mycelium showing clamp connections and anastomoses.

Polyporus versicolor.

FIG. 8. Binucleated hyphal cells from old mycelium showing clamp connections, anastomoses, hemispherical discs.

Boletus granulatus.

FIG. 9. Cells from the stipe.

FIG. 10. Cells from the ring.

PLATE 5

Polyporus destructor.

FIG. 5. Binucleated cells from old mycelium.

FIG. 6. Two adjacent binucleated cells with clamp connections.

Boletus granulatus.

FIG. 11. Binucleated cells from the flesh of the pileus.

FIG. 13. Young binucleated cystidium.

FIG. 15. Mature and very young cystidium showing connection with hyphal cells in the trama. Line over mature cystidium indicates surface of gelatinous excretion.

FIG. 32. Cross section of basidium showing four daughter nuclei telophase stage.

FIG. 37. Four nuclei a little below the middle of the basidium attached to the tips of the sterigmata by fibrillar strands.

FIG. 41. Basidium showing the nuclei in the sterigmata attached to the tips of the spores by fibrillar strands.

FIG. 42. Nuclear division in the spore in equatorial plate stage.

FIG. 44. Same as FIG. 42, diaster stage.

Boletus castaneus.

FIG. 70. Primary nuclei in basidium.

FIG. 76. Nuclear division in spore showing spindles with centrosomes and astral rays, equatorial plate stage.

Boletus chrysenteron.

FIG. 77. An abnormal basidium showing one of the sterigmata fully formed while the two daughter nuclei are still dividing.

PLATE 6

Boletus granulatus.

FIG. 14. Mature and young cystidia.

FIG. 16, 17. Young basidia with primary nuclei preparing to fuse.

FIG. 18. Basidium showing nuclear fusion.

FIG. 19, 20. Basidium with nucleus in spirem stage.

FIG. 21. Longitudinally split spirem.

FIG. 22. Segmented spirem.

FIG. 23. First nuclear division showing eight chromosomes, metaphase.

FIG. 25. The chromosomes moving toward the poles, anaphase.

FIG. 25*a*. The chromosomes at the poles before fusing, diaster.

FIG. 26. Cross section of basidium showing two young daughter nuclei, telophase.

FIG. 27. Diaster, second division, a number of nuclei at each pole.

FIG. 28, 29. Cross section of basidium, same as FIG. 27; chromosomes fused into two masses.

FIG. 30, 31. Early telophase of the four daughter nuclei.

FIG. 33. Four nuclei beginning to move toward base of basidium, nucleus to right is attached to centrosome on basidium wall by kinoplasmic fibers.

FIG. 34, 35. Early stages in the development of the sterigmata, fibrillar strands connect the nuclei and the tips of the sterigmata.

FIG. 45. Young four-nucleated hymenial cell in which nuclear division was not followed by cell division.

Boletus castaneus.

FIG. 72. Cross section of basidium, first division, the chromosomes massed together.

FIG. 73. Same as FIG. 72, six to eight chromosomes.

FIG. 74. Nuclei moving to base of basidium.

PLATE 7

Boletus granulatus.

FIG. 12. A cluster of cystidia forming a gelatinous granule, from the mouth of a pore.

FIG. 24. First division in the basidium, anaphase, showing a number of chromosomes, the poles lying on the basidium wall.

FIG. 36. Basidium with four nuclei attached to young sterigmata.

FIG. 38. Basidium with very young spore buds.

FIG. 39. A slightly older stage; fibrillar strands distinctly visible running through the spore body connecting centrosomes and nuclei.

FIG. 40. An older stage; fibrillar strands; nuclei moving toward the spores.

Boletus albellus.

FIG. 61. Resting nucleus with a conspicuous red-staining body lying between it and the basidium wall.

FIG. 62. First division, anaphase, with well-marked centrosomes and astral rays.

FIG. 63. Nucleus in a sterigma.

Boletus castaneus.

FIG. 71. A spirem stage.

FIG. 75. Basidium with the nuclei in the sterigmata, attached by fibers to the centrosomes at the apices of the spore.

Boletus chrysenteron.

FIG. 78. Nuclei attached to the tips of sterigmata by kinoplasmic fibers.

FIG. 79. Nuclear division in the spore; spindles with centrosomes and astral rays. Chromosomes in equatorial plate stage.

PLATE 8

Boletus granulatus.

FIG. 43. Nuclear division in spores, anaphase.

Boletus versipellis.

FIG. 46. Basidia with primary and secondary nuclei.

FIG. 47, 48, 49. Nuclear fusions in the basidium.

FIG. 50. Spirem stage.

FIG. 51, 52, 53. First division in the basidium, varying appearance of the equatorial plate stage.

FIG. 54, 55. Diaster, stages of the first division.

FIG. 56. Two daughter nuclei attached to wall of basidium, astral rays still present, late telophase.

FIG. 57. A prophase stage of the second division.

FIG. 58, 59. Second division in the basidium, spindle with centrosomes and astral rays, chromosomes in equatorial plate stage.

FIG. 60. Cystidium with two sharply differentiated nuclei, to the left is a basidium.

Boletus albellus.

FIG. 64. Spore with single nucleus.

FIG. 65. First division in spore, diaster stage.

FIG. 66. Binucleated spore.

FIG. 67. Second division, spindles with centrosomes and astral rays, chromosomes in equatorial plate stage.

FIG. 68. Similar stage, only one spindle is figured; several chromosomes are shown.

FIG. 69. A spore with three nuclei.

New ferns from tropical America—II

MARGARET SLOSSON

(WITH PLATE 3)

The two species of *Dryopteris* here described for the first time belong to the group of *D. pubescens*. Both are from Jamaica, and each bears a most curious and misleading resemblance to the other.

For the privilege of describing the first I am indebted to the kindness of Mr. William R. Maxon. This species is based on a single sheet, representing a rootstock and three leaves, two detached, originally from the Jenman Herbarium, labelled *Nephrodium luridum* Jenman, in Jenman's hand. It may be described as follows:

Dryopteris lurida (Jenman) Underwood & Maxon sp. nov.
Nephrodium luridum Jenman MS.

Rhizome creeping, furnished with blackish rigid lanceolate or lance-linear acuminate scales up to 6 mm. long, with occasional unicellular gland-like processes and jointed cilia on their margins; similar scales on bases of the stipes; fronds clustered, pubescent, glandular throughout with capitate, often long-stalked and jointed, sometimes forked glands; stipes slender, up to 31.5 cm. long, dark brown at base, upwards brownish or stramineous or greenish, grooved on face; laminae up to 25 cm. long, up to 16.5 cm. broad, green, tinged with olive, ovate-deltoid, tripinnate, abruptly narrowed above at about the third or fourth pair of pinnae, their apices acute or acuminate, serrate, giving rise gradually to the pinnae and pinnules; pinnae alternate or opposite, oblique, stalked, mostly asymmetrical, those above the basal mostly ovate-lanceolate to oblong-lanceolate, the second or third pair often subequilateral, those above somewhat cut away beneath at base, the basal pair broadly deltoid or ovate-deltoid, up to 9 cm. broad at base, its inner inferior 2–5 pinnules on either side much longer than the corresponding superior ones and sometimes subbipinnate at base; other pinnules parallel with or overlapping the costa on the inner side, somewhat cut away beneath at base, acute, the larger stalked and obliquely pinnatifid into serrate or entire lobes,

the smaller subdimidiate, serrate and decurrent; texture thin, membrano-herbaceous; pubescence white or whitish, setaceous, multicellular, the facial grooves of the stipes and the backs of the costae thickly coated with short fine soft hairs which spread part way up the midribs of the pinnules, larger coarser stiffer hairs scattered over the stipes, costae, backs of the veins on the under surface of the lamina, and between the veins on its upper surface; veins clearly visible, pinnate; sori apical on the veinlets, midway between the midvein and the margin of the lamina, sterile veinlets mostly extending almost to the margin; indusia glandular, not setose; sporangia glabrous; spores coarsely papillose. [PLATE 3, FIGURE 1.]

Type in the Underwood Herbarium at the New York Botanical Garden, collected in Jamaica "1874–79."

The following specimens also are in the Underwood Herbarium:

JAMAICA: Mt. Diabolo, altitude 609 meters, April 2, 1903, *Underwood 1825;* vicinity of Hollymount, Mt. Diabolo, May 9, 1903, *Maxon 1957;* vicinity of Hollymount, altitude about 750 meters, May 25–27, 1904, *Maxon 2311, 2260.*

Dryopteris leucochaete Slosson sp. nov.

Rhizome creeping, slightly chaffy; fronds clustered, pubescent and glandular; stipes up to 35.5 cm. long, brown and slightly chaffy at base, above greenish to brownish, grooved on face; scales soft, pale brown, lanceolate, acuminate, up to 3 mm. long, with slightly ciliate or subglandular margins; laminae up to 28 cm. long and 25 cm. broad, mostly subpentagonal, commonly quadripinnate, abruptly narrowed above, apices mostly long-acuminate and serrate; pinnae oblique, stalked, asymmetrical, basal pair ovate-deltoid to deltoid; pinnules oblique, stalked to decurrent, several of the inferior elongate in the basal pinnae and shortened in the upper; segments oblique, stalked to decurrent, unequally ovate to subtrapezioid, cut away at base, pinnate or obliquely pinnatifid to serrate; glands capitate, often jointed, sometimes forked; pubescence white, setaceous, multicellular, fine and short hairs abundant on the groove of the stipe, backs of the costae, and partly on the midribs of the pinnules, larger, coarser, scattered hairs on the general surface of the stipes, costae, and backs of the veins, and between the veins on the upper surface of the lamina; veins pinnate; sori apical on the veinlets, midway between the midvein and margin of the lamina; indusia conspicuously setose and glandular; sporangia glabrous; spores papillose. [PLATE 3, FIGURE 2.]

Type in the Underwood Herbarium at the New York Botanical Garden, collected on shady forest land in Peckham Woods, Clarendon, Jamaica, altitude 762 meters, May 21, 1912, *William Harris 11023*.

This species differs from *D. lurida* chiefly in its smaller, soft, pale, almost tow-colored scales, its larger, more finely divided lamina, and its setose indusia. Additional specimens are: Jamaica; vicinity of Troy, altitude 600–660 meters, June 28, 1904, *Maxon 2860;* in rocky woodland, near Troy, altitude 701 meters, June 28, 1904, *Harris 8710*.

Explanation of plate 3

FIG. 1. *Dryopteris lurida;* Jamaica; parts of the type specimen, reduced.

FIG. 2. *Dryopteris leucochaete;* Jamaica; leaf, reduced, *Maxon 2860.*

INDEX TO AMERICAN BOTANICAL LITERATURE

(1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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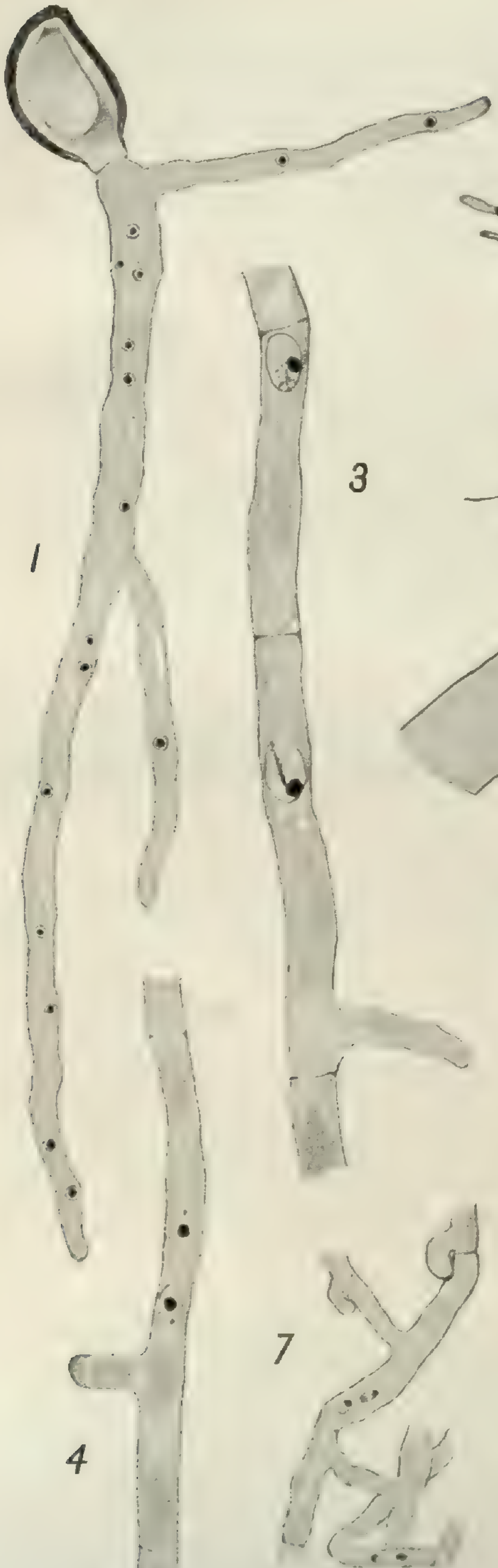
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LEVINE: CYTOLOGY OF HYMENOMYCETES

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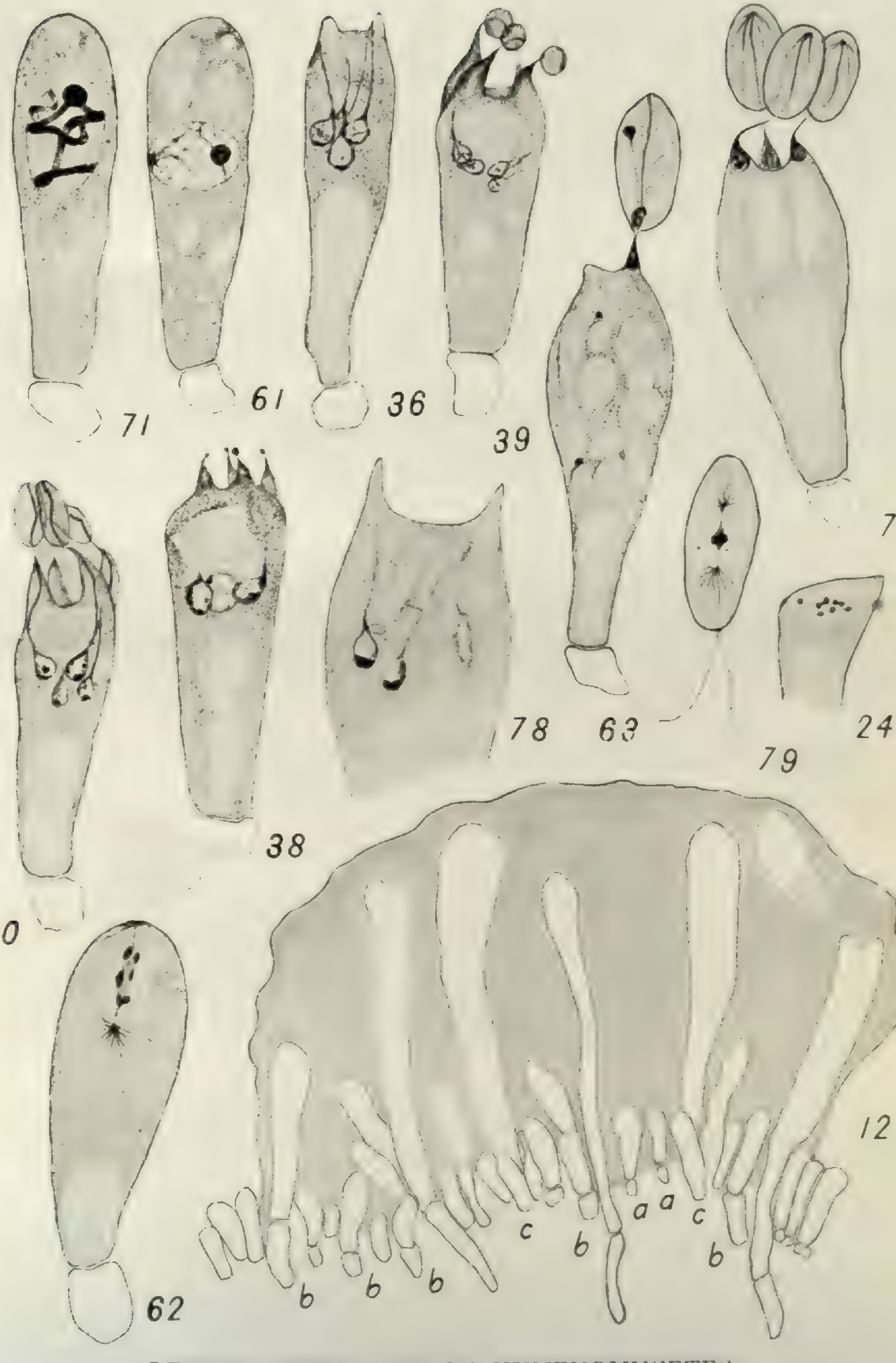
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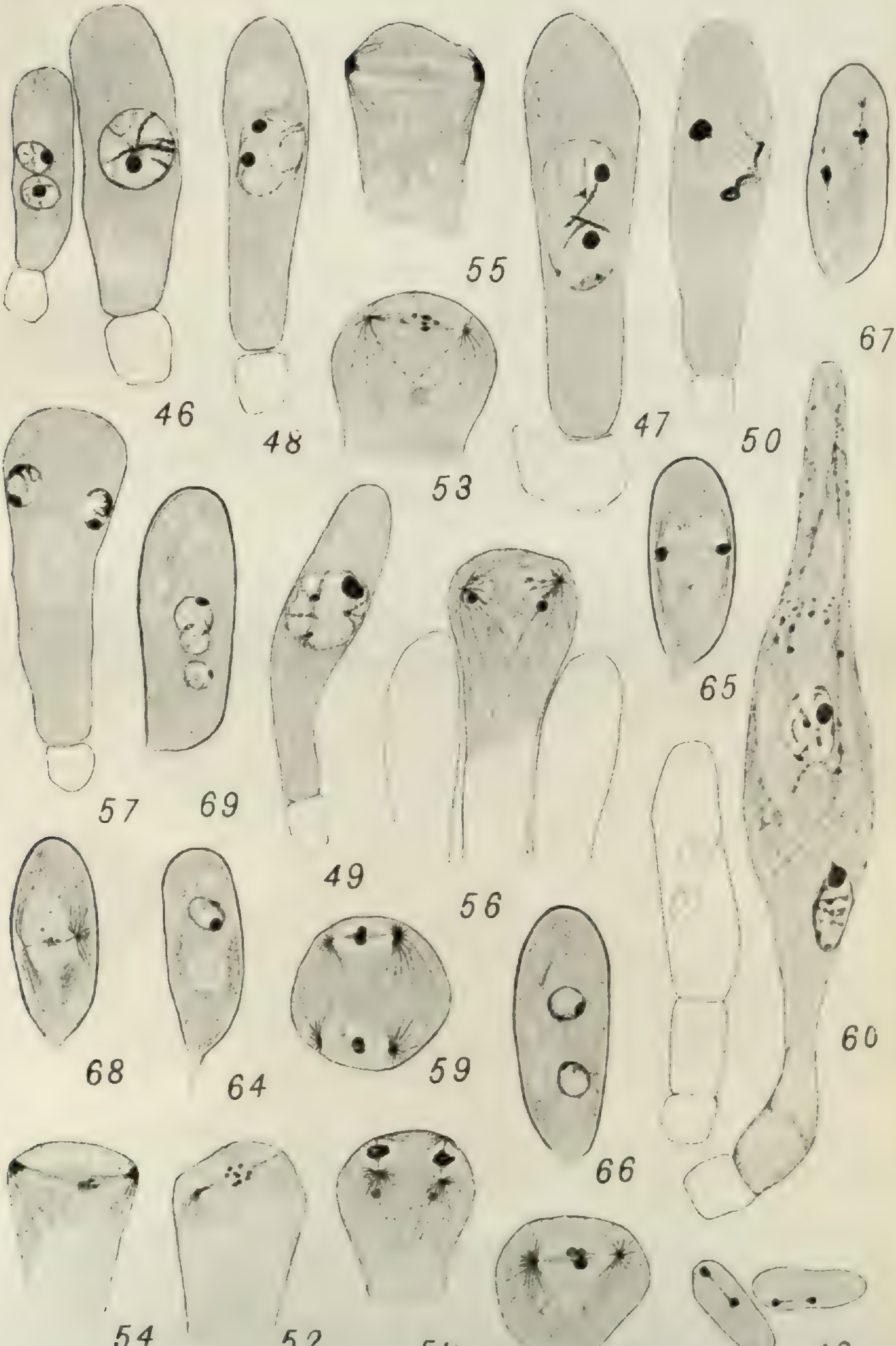
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Vol. 40 No. 5

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1913

A taxonomic study of the Pteridophyta of the Hawaiian Islands—III

WINIFRED J. ROBINSON

(WITH PLATES 9–12)

19. POLYPODIUM L. Sp. Pl. 1082. 1753

A cosmopolitan genus, including ferns of every habitat. Rootstock creeping; leaves articulate; blades various, mostly simple or pinnate; veins free or occasionally anastomosing; sori orbicular, dorsal on the veins, non-indusiate.

Type species: *Polypodium vulgare* L.

Leaves simple to deeply pinnatifid, not bearing reddish, resinous glands beneath.
  Leaves simple.
    Margin entire or very slightly undulate.
      Rootstock creeping, 5–8 mm. in diameter, the scales light brown; leaves 8–20 cm. × 7.5–10 mm.
        Leaves stalked, pubescent with numerous reddish brown hairs 2–3 mm. long; margin entire; sori inframedial. *P. Hookeri.*
        Leaves sessile, pubescent with scattered whitish hairs less than 1 mm. long; margin slightly undulate; sori supramedial. *P. Knudsenii.*
      Rootstock erect or creeping, less than 5 mm. in diameter, the scales dark brown; leaves 5–7 cm. × 2–5 mm.
        Rootstock erect, rather stout; leaves subsessile, linear-lanceolate, entire; sori oval, numerous. *P. pumilum.*
        Rootstock creeping, wiry; leaves stalked, linear, slightly undulate; sori round, few, distant. *P. pseudogrammitis.*

[The BULLETIN for April 1913 (40: 137-192. *pl. 3–8*) was issued May 9.]

Margin crenate to serrate, at least in the lower part; rootstock erect; leaves 10–15 cm. × 2–4 mm.
Margin crenate or dentate from base to apex; sori oval, alternate, supramedial on serrations. *P. Haaliliolanum.*
Margin sinuately pinnatifid below, subentire in apical third; sori oval, inframedial. *P. Saffordii.*

Leaves pinnatifid.
Basal segments reduced to a wing along the midrib; lower surface and margin marked by scattered, brownish glandular hairs.
Leaves elliptic-lanceolate to elliptic-caudate, 8–15 cm. × 1–2.5 cm.; sori nearly covering leaf tissue from costa to margin. *P. sarmentosum.*
Leaves linear to narrowly oblanceolate, 15–25 cm. × 1.5–2 cm.; sori inframedial. *P. Adenophorus.*
Basal segments scarcely reduced; leaves ovate-oblong, segments varying from linear to lanceolate with narrow sinuses between them, to oblong and obtuse with broad sinuses; pellucid lines between the veins. *P. pellucidum.*

Leaves bipinnatifid to deeply tripinnatifid, bearing numerous, reddish, resinous glands beneath.
Leaves bipinnatifid.
Leaves linear, 5–15 cm. × 5–7.5 mm., pinnae divided into 2 or 3 segments. *P. hymenophylloides.*
Leaves not linear; pinnae divided into 6 to 15 segments.
Leafstalk 0.5 mm. in diameter; blades oblong-ovate, 3.5–5 cm. × 1–2 cm.; pinnae compact. *P. abietinum.*
Leafstalk 1–2 mm. in diameter; blades more than 10 cm. long.
Leaves subcoriaceous, blades ovate-lanceolate; pinnae oblong, 20–30 cm. × 6–8 cm.; segments linear; sori narrower than the segments. *P. Hillebrandii.*
Leaves chartaceous, blades elliptic-lanceolate to elliptic-caudate, 10–35 cm. × 2–5 cm., pinnae lanceolate; segments oblanceolate to spatulate; sori as broad as the segments. *P. tamariscinum.*
Leaves tripinnatifid; pinnae 15–25 cm. × 2–3 cm.; segments spatulate; sori as broad as the segments. *P. Gaudichaudii.*

POLYPODIUM HOOKERI Brack. Fil. U. S. Expl. Exp. 4. 1854

Polypodium setigerum Hook. & Arn. Bot. Beech. 103. 1832. Not Blume.

Grammitis setigera J. Sm. Hist. Fil. 181. 1875.

TYPE LOCALITY: Oahu.

DISTRIBUTION: Polynesia, Hawaiian Islands.

ILLUSTRATION: Hook. & Arn. Bot. Beech. *pl. 21. f. a.* 1832.

SPECIMENS EXAMINED: Hawaii, *Mann & Brigham 482* N; *Robinson 201* V; Maui, *Robinson 336* V; *338* V; *352* V; Oahu, *Heller 2245* C, N; *Lichtenthaler* N; Hawaiian Islands, *Baldwin 81* C, N; *Baldwin* B; *Hillebrand* B; ex Herb. Underwood C; *Hillebrand* N.

This is closely allied to *P. setosum* (Blume) Presl, according to Copeland, Polypodiaceae of the Philippine Islands, Bur. Gov. Lab. Publ. **21**: 119. 1905.

POLYPODIUM KNUDSENII Hieron. Hedwigia **44**[2]: 79. 1905

Polypodium samoense var. *glabra* Hilleb. Fl. Haw. Is. 554. 1888. Not *P. glabrum* Roxb.

Polypodium samoense Christ in Engler, Bot. Jahrb. **23**: 358. 1896, in part. Not Baker.

TYPE LOCALITY: Kauai, Hawaiian Islands.

DISTRIBUTION: On trees, Kauai, Hawaiian Islands.

SPECIMENS EXAMINED: Kauai, *Baldwin 17* B; *Heller 2708* B; C, K, N; *Knudsen 7* B; *Robinson 405* V; *440* V; *453* V; *826* V; *836* V.

Hieronymus (Hedwigia **44**[2]: 79. 1905) distinguishes *P. Knudsenii* from *P. samoense* by the broader, yellow rather than ferruginous, scales of the rhizome; the fewer, smaller hairs upon the leafstalk; the thicker texture and more pointed apex of the leaf; the less evident veins; the larger size of the sori and their greater proximity to the margin of the leaf.

Polypodium pumilum sp. nov.

Rootstock short, erect, less than 1 mm. in diameter, covered with dark brown, linear-lanceolate scales 1–2 mm. long and 0.3–0.5 mm. broad at the base, with 6–10 rows of cells in the broadest part; roots numerous; leaves 3–5, simple, nearly sessile, cespitose, linear-oblanceolate, obtuse or bluntly acute at apex, narrowed gradually at the base, 4–7 cm. long, 3–5 mm. wide, the margin subentire, the midrib green, prominent; veins forked once about 2 mm. from the midrib; sori oblong, 1.5–2 mm. long by 1–1.5 mm. broad; sporangia flattened laterally, the annulus of 10–12 cells; spores yellow, tetrahedral, 0.040 mm. in diameter, very minutely tuberculate. [FIG. 1.]

Type collected on Oahu, 1000 m. elevation, 1890, by D. D. Baldwin, distributed by D. C. Eaton as *P. sessilifolium* (herb. N. Y. Bot. Gard.).

Known only from the type locality.

The present species differs from *P. Knudsenii* Hieron. in its smaller size; in the size of the scales, which in the latter are 3–4

FIG. 1. *Polypodium pumilum*, natural size.

mm. long and 0.5–0.8 mm. wide, with 10–20 rows of cells in the broadest part; and in the smooth margin of the leaf in contrast with the hairy margin of *P. Knudsenii*.

POLYPODIUM PSEUDOGRAMMITIS Gaud. Voy. Freyc. Bot. 345. 1828

Grammitis tenella Kaulf. Enum. 84. 1824. Not Forster.

Polypodium Kaulfussii Presl, Tent. Pterid. 178. 1836.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On trees, common; Hawaiian Islands.

ILLUSTRATIONS: Hook. & Arn. Bot. Beech. *pl. 21.* 1832; Kunze, Anal. Pterid. *pl. 9. f. 1.* 1837.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B, C; *Robinson 236* V; *260* V; *275* V; Oahu, *Heller 2215* C; *Macrae* B; *Robinson 2* V; *9* V; *45* V; *119* V; Kauai, *Robinson 446* V; Hawaiian Islands, *Baldwin 32* B; *83* B, C; *Gaudichaud* B; *Wilkes Expedition* B, C.

POLYPODIUM HAALILIOLANUM Brack. Fil. U. S. Expl. Exp. 5. 1854

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: On tree trunks above 600 m. elevation, Hawaiian Islands; rare.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 1. f. 4.* 1854.

SPECIMENS EXAMINED: Hawaii, *Robinson 601* V; Oahu, *Hillebrand* B; *Mann & Brigham 178* N; *Wilkes Expedition* N; Kauai, *Lichtenthaler* N; Hawaiian Islands, *Baldwin 86* B; C; *Hillebrand* C.

Hieronymus (Hedwigia **44**[2]: 86. 1905) reduces *Polypodium Haaliliolanum* to *Polypodium subpinnatifidum* Blume, but the type of the latter at Berlin has subpinnatifid lobes and acute sinuses, while the leaves of the Hawaiian plant are sinuato-crenate throughout. The sporangia of *Polypodium Haaliliolanum* are smooth, while those of *Polypodium subpinnatifidum* are setose.

POLYPODIUM SAFFORDII Maxon, Am. Fern Jour. **2**: 19. 1912

Polypodium minimum Brack. Fil. U. S. Expl. Exp. 5. *pl. 1. f. 3.* 1854. Not Aublet.

Polypodium serrulatum var. *lata* Luerssen, in Wawra, Flora **58**: 422. 1875.

Polypodium serrulatum Hilleb. Fl. Haw. Is. 553. 1888. Not Mett.

TYPE LOCALITY: Oahu.

DISTRIBUTION: Common on trees above 600 m. elevation, Hawaiian Islands.

ILLUSTRATIONS: Brack. Fil. U. S. Expl. Exp. *pl. 1. f. 3.* 1854; Maxon, Am. Fern Jour. **2**: 19. 1912.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; *Robinson 600* V; Oahu, *Heller 2905* (type) N, (cotype) C; *Mann & Brigham 550* N; *Robinson 521* V; *Wilkes Expedition* N; Kauai, *Hillebrand 123* B; Hawaiian Islands, *Baldwin 85* B, C; *Bishop 81* B; *Johnson* B; ex Herb. Mt. Holyoke College B; *Wilkes Expedition* C.

POLYPODIUM SARMENTOSUM Brack. Fil. U. S. Expl. Exp. 8. 1854

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Common on rocks and decayed wood, Hawaiian Islands.

ILLUSTRATION: Brack. Fil. U.S. Expl. Exp. *pl. 2. f. 3.* 1854.

SPECIMENS EXAMINED: Hawaii, *Robinson 203* V; Maui, *Bailey* C; *Robinson 356* V; Oahu, *Forbes* BM; *Heller 2353* C, N; *Lichtenthaler* N; *Mann & Brigham 200* N; *Robinson 1* V; *5* V; *46* V; *67* V; *117* V; *Safford 889* N; Kauai, *Robinson 856* V; *418* V; Hawaiian Islands, *Baldwin 82* C, N; *Wilkes Expedition* C; ex Herb. John Donnell Smith N.

POLYPODIUM ADENOPHORUS Hook. & Arn. Bot. Beech. 104. 1832

Adenophorus pinnatifidus Gaud. Voy. Freyc. Bot. 365. 1829. Not Gilib.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: On tree trunks in the forests above 600 m. elevation.

ILLUSTRATION: Hook. & Arn. Bot. Beech. *pl. 22.* 1832.

SPECIMENS EXAMINED: Oahu, *Lichtenthaler* N; *Mann & Brigham 283* N; Kauai, *Knudsen* B; *Robinson 851* V; Hawaiian Islands, *Baldwin 88* B, C; *Wilkes Expedition* C, N; ex Herb. John Donnell Smith N.

POLYPODIUM PELLUCIDUM Kaulf. Enum. 101. 1824

Polypodium myriocarpum Hook. Ic. Pl. *pl. 84.* 1837.

Polypodium hawaiiense Underw. in Heller, Minn. Bot. Stud. 1: 784. 1897.

Polypodium Helleri Underw. in Heller, Minn. Bot. Stud. 1: 785. 1897.

Polypodium vulgare Christ, Farnkr. Erde 83. 1909.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On ground and on tree trunks, at 300–2,000 m. elevation; Hawaiian Islands.

ILLUSTRATIONS: Hook. Ic. Pl. *pl. 84.* 1837; *pl. 944, 945.* 1854.

SPECIMENS EXAMINED: Hawaii, *Dale* C; *Robinson 144* V; *254* V; *267* V; *Wilkes Expedition* C; Maui, *Bishop 83* B; *84* B; *Finsch 11* B; *60* B; *Robinson 316* V; *324* V; *333* V; Molokai, *Hillebrand* B; Oahu, *Chamisso* B; *Forbes 1017* BM; *Heller 2075* C; *Robinson 7* V; Kauai, *Forbes 268* BM; *Heller 2602* C; *2634* C; *Hillebrand 54* B; *Knudsen 55* B; *56* B; *Robinson 403* V; *482* V; Hawaiian Islands,

Baldwin 89a B; *89c* B; *89* C; *Bailey* C; *Douglas 69* B, C; *Gaudichaud* B; *Lydgate* B; *Wilkes Expedition* B, C.

Polypodium pellucidum is extremely polymorphous, as is shown by the several nominal species that have been segregated at different times. Kaulfuss's type in the Berlin herbarium is very coriaceous and has the intermediate veinlike striations mentioned by this author. The pinnae are rather acute, 4–5 cm. long, with crenate-undulate margins. Divergences from this are seen in: (1) *P. Helleri* Underw. (type *Heller 2602*) with longer thinner pinnae; a single incomplete leaf has greatly elongated pinnae; (2) *P. hawaiiense* Underw. with broader (1.5 cm.), shorter (3–4.5 cm.), rounded pinnae, Hillebrand's var. *opacum* from Molokai; (3) *P. myriocarpum* (Hook. Ic. Pl. 1: *pl. 84*) apparently a monstrous form with great variability in the pinnae of the same leaf; (4) a form still more common in collections, which has close or spaced pinnae ranging from rounded to pointed on the same leaf. Near the extinct craters, about a mile from the Volcano House, Hawaii, the leaves are folded ventrally upon the midrib. A field study of the range of variations of the species would form an interesting local problem.

POLYPODIUM HYMENOPHYLLOIDES Kaulf. Enum. Fil. 118. 1824

Amphoradenium minutum Desv. Prod. 336. 1827.

Adenophorus hymenophylloides Hook. & Grev. Ic. Fil. *pl. 176.* 1829.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Rare, on trees at elevations of 1,000–1,600 m., Hawaiian Islands.

ILLUSTRATIONS: Gaud. Voy. Freyc. Bot. *pl. 8.* Hook. & Grev. Ic. Fil. *pl. 176.* 1829.

SPECIMENS EXAMINED: Hawaii, *Robinson 276* V; forest above Cape Lua Pele, *Wilkes Expedition* N; *Wilkes Expedition 19* B, C; Maui, *Robinson 347* V; *Wilkes Expedition* B, C, N; Oahu, *Beechey* C; *Diell* C; *Robinson 87* V; *97* V; Kauai, *Heller 2213* C, N; *Knudsen 154* B; *Robinson 462* V; Hawaiian Islands, *Baldwin 90* B, C, N; *Gaudichaud* B, C; *Hillebrand* B; *Mann & Brigham 276* N.

POLYPODIUM ABIETINUM D. C. Eaton, in Mann, Proc. Am. Acad. 7: 219. 1867

Polypodium tamariscinum var. *abietinum* Hilleb. Fl. Haw. Is. 557. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: On trees, rare; Hawaiian Islands.

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; Oahu, *Hillebrand* B; *Remy* C; *Robinson 32* V; *48* V; *Wilkes Expedition* N; Kauai, *Heller 2732* C; N; *Hillebrand* B; *Lichtenthaler* N; Hawaiian Islands, *Baldwin 94* B; C; *Hillebrand* B.

POLYPODIUM HILLEBRANDII Hook. Sp. Fil. 4: 228. 1862

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: At 400–700 m. elevation, rare; Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. 4: *pl. 279A*. 1862.

SPECIMENS EXAMINED: Hawaii, *Robinson 287* V; Oahu, *Forbes* BM; *Robinson 23* V; *123* V; Hawaiian Islands, *Baldwin 92* C, N; *Baldwin 93* C; *Hillebrand* B, C; *Safford 891* N; ex Herb. John Donnell Smith N; *Wilkes Expedition* C.

POLYPODIUM TAMARISCINUM Kaulf. Enum. Fil. 117. 1824

Adenophorus bipinnatus Gaud. Ann. Sci. Nat. 3: 508. 1824.

TYPE LOCALITY: Oahu.

DISTRIBUTION: Hawaiian Islands.

ILLUSTRATION: Hook. & Grev. *pl. 175*. 1829.

SPECIMENS EXAMINED: Hawaii, *Robinson 208* V; *248* V; Oahu, *Copeland* N; *Heller 2214* N; *Lichtenthaler* N; *Mann & Brigham 198* N; *Robinson 83* V; *91* V; *92* V; *118* V; *122* V; *Safford 892* N; Kauai, *Robinson 463* V; *495* V; *832* V; Hawaiian Islands, *Baldwin 91* N; ex Herb. John Donnell Smith N.

POLYPODIUM TRIPINNATIFIDUM (Gaud.) Presl, Tent. Pterid. 178. 1836

Adenophorus tripinnatifida Gaud. Ann. Sci. Nat. 3: 508. 1824; Voy. Freyc. Bot. *pl. 8*. 1826.

Amphoradenium Gaudichaudii Desv. Prod. 336. 1827.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Above 600 m. elevation, Hawaiian Islands.

ILLUSTRATION: Gaud. Voy. Freyc. Bot. *pl. 8.*

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; Maui, *Lichtenthaler* N; Molokai, *Baldwin 93a* B; *93b* B; Kauai, *Remy 16* C; Hawaiian Islands, *Hillebrand 122* B; *Wilkes Expedition 20* B, C.

20. PHYMATODES Presl, Tent. Pterid. 195. 1836

Tropical plants, mostly epiphytic; rootstock creeping; leaves articulate, distant, simple; veins obscure or prominent, anastomosing, with free included veinlets; sorus borne upon anastomosing veins or upon the clavate apex of an included vein, non-indusiate.

Type species: *Polypodium zosteraeforme* Wall.

Leaves linear-lanceolate; veins obscure; sori round, nearly covering leaf from costa to margin, light brown.	*P. elongata.*
Leaves palmately lobed; veins prominent; sori small, dark.	*P. Spectrum.*

PHYMATODES ELONGATA Presl, Tent. Pterid. 196. 1836

Polypodium lineare Thunb. Fl. Jap. 335. 1784. Not Burm.
Pleopeltis nuda Hook. Fil. Exot. 63. 1823.
Pleopeltis linearis Kaulf. Enum. 246. 1824.
Pleopeltis Thunbergiana Kaulf. Wes. d. Farrenkr. 113. 1827.
Polypodium leiopteris Kunze, Klotzsch, Linnaea **23**: 319. 1850.
Drynaria nuda Fée, Gen. **1**: 270. 1850–52.
Drynaria elongata Brack. Fil. U. S. Expl. Exp. 42. 1854.
Niphobolus linearis Keyserl. Polyp. Cyath. Herb. Bung. 39. 1873.

TYPE LOCALITY: Kosido, Japan.

DISTRIBUTION: On trees and rocks; tropical countries.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; Maui, *Wilkes Expedition* N; *O. Finsch 10* C; Kauai, *Heller 2533* C; *3533* N; Oahu, *Wilkes Expedition* C; *Diell* C; *Heller 2005* C, N; *2076* C, N; *2031* C, N; *Mann & Brigham 177* N; *Robinson 84* V; *Safford 893* N; *1887* N; Hawaiian Islands, *Baldwin 82* C, N; *R. H. Hitchcock* C; ex Herb. John Donnell Smith N.

PHYMATODES SPECTRUM (Kaulf.) Presl, Tent. Pterid. 197. 1836

Polypodium Spectrum Kaulf. Enum. 94. 1824.
Polypodium Thouinianum Gaud. Voy. Freyc. Bot. 348. 1828.

Drynaria spectrum J. Sm. Jour. Bot. Hook. 4: 61. 1842.
Pleopeltis spectrum Moore, Ind. Fil. 348. 1862.
Colysis Spectra J. Sm. Ferns Brit. & For. 98. 1866.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On rocks and tree trunks in dense shade of woods, Hawaiian Islands, Sumatra.

ILLUSTRATIONS: Gaud. Voy. Freyc. Bot. *pl. 5. f. 1.* E. & P. Nat. Pfl. 1^4: 317. *f. 164A, B.* 1899.

SPECIMENS EXAMINED: Hawaii, *Robinson 200* V; Maui, *Wilkes Expedition* C; Oahu, *Heller 2118* C; *Robinson* V; Kauai, *Heller 2438* C; Hawaiian Islands, *Baldwin 84* C; *Miss Sessions* C; ex Herb. Kew. C.

The leaves of *Phymatodes Spectrum* vary so much in size and cutting of the lobes as to suggest different species for those found growing upon a single rootstock.

21. PHLEBODIUM (R. Br.) J. Sm. Jour. Bot. 4: 58. 1842

Tropical or subtropical plants, usually epiphytic. Rootstock creeping, 1–2 cm. in diameter, paleaceous; leaves articulate; blades pinnatifid or pinnate; primary veins pinnately arranged, the secondary veins anastomosing; sori usually terminal on two included veinlets, non-indusiate.

Type species: *Polypodium aureum* L.

PHLEBODIUM AUREUM (L.) J. Sm. Jour. Bot. Hook. 4: 58. 1842

TYPE LOCALITY: West Indies.

DISTRIBUTION: On ground and on trees, West Indies, Florida, Mexico, Brazil, Hawaiian Islands.

ILLUSTRATIONS: Plumier, Traité Foug. *pl. 76.* 1705. PLATE 9.

SPECIMENS EXAMINED: Wahiawa Mts., Kauai, *Forbes 308* BM.

Forbes 308 is the first collection of this species that has been noted for the Hawaiian Islands, and it may be that it is an escape from cultivation, though the remoteness of the locality where it was collected makes its origin from a cultivated plant improbable.

Mr. Forbes notes: "All the fronds were remarkably glaucous blue."

22. POLYSTICHUM Roth, Röm. Mag. 2^1: 106. 1799

Mostly coarse and rigid terrestrial plants of cosmopolitan distribution; rootstock short, erect; leaves cespitose, not articu-

late; blades pinnate to quadripinnate; veins free; sori roundish, dorsal upon the veins; indusium centrally peltate, orbicular.

Type species: *Polypodium Lonchitis* L.

Leaves tripinnate, ovate-lanceolate, smooth or slightly tomentose. *P. carvifolium.*
Leaves bipinnate; stipe and rachis densely covered with linear-lanceolate scales.
Pinnae 1.5–3 cm. apart, sharply aristate. *P. haleakalense.*
Pinnae crowded, margins entire or nearly so. *P. Hillebrandii.*

POLYSTICHUM CARVIFOLIUM (Kunze) C. Chr. Ind. Fil. 70. 1905

Polystichum coniifolium J. Sm. Jour. Bot. Hook. 3: 413. 1841. Not Presl.

Aspidium curvifolium Kunze, Bot. Zeit. 6: 283. 1848.

Aspidium aristatum Sw. var. *coniifolium* Wall.; Hook. Sp. Fil. 4: 27. 1862.

Dryopteris coniifolia Underw. in Heller, Minn. Bot. Stud. 1: 778. 1897.

TYPE LOCALITY: Philippine Islands.

DISTRIBUTION: High plateaus, China, Japan, Polynesia, Hawaiian Islands, Australia.

SPECIMENS EXAMINED: *Heller 2817* C; *Baldwin 62* C.

The habit, coriaceous texture, and aristate pinnae of this plant place it in *Polystichum* rather than in *Dryopteris.* The indusia are sometimes reniform-orbicular, sometimes peltate, on the same leaf. It is very different from the Japanese *Polystichum aristatum* (Forster) Presl, in rootstock, texture, and the division of the leaf.

POLYSTICHUM HALEAKALENSE Brack. Fil. U. S. Expl. Exp. 204. 1854

Aspidium haleakalense Mann, Proc. Am. Acad. 7: 216. 1867.

Aspidium aculeatum var. *Braunii* Hilleb. Fl. Haw. Is. 568. 1888. Not Swartz.

TYPE LOCALITY: Region of Sophora, Mauna Kea, Hawaii.

DISTRIBUTION: In forests at altitudes of 1,800–2,700 m., Hawaiian Islands.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 28.* 1854.

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; Maui, *Lichtenthaler* N; *Finsch 45* B; *Lydgate* B; *Lydgate & Baldwin* B; *Mann & Brigham 481* N; *Mann* B; ex Herb. Mt. Holyoke College C; Oahu, *Macrae* B; Hawaiian Islands, *Baldwin 61* C, N; ex Herb. John Donnell Smith N.

POLYSTICHUM HILLEBRANDII Carruth. in Seem. Fl. Vit. 358. 1873

Aspidium Hillebrandi Hilleb. Fl. Haw. Is. 568. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: In forests at altitudes of 1,500–1,800 m., Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Bailey* C; *Baldwin* B, C, V; *Lydgate* B; Hawaiian Islands, *Baldwin 60* B, C.

23. CYRTOMIUM Presl, Tent. Pterid. 86. 1836

Rootstock short; leaves clustered, pinnate, somewhat coriaceous; veins anastomosing; sori globose, dorsal upon free included veinlets or upon connecting veins; indusium peltate.

Type species: *Cyrtomium caryotideum* (Wall.) Presl.

Leaves less than 15 cm. long, with a single row of areolae on either side of the midvein. *C. Boydiae.*

Leaves more than 15 cm. long, with several areolae between midrib and margin. *C. caryotideum.*

Cyrtomium Boydiae (D. C. Eaton) comb. nov.

Aspidium Boydiae D. C. Eaton, Bull. Torrey Club **6**: 361. 1879.

Aspidium cyatheoides var. *depauperatum* Hilleb. Fl. Haw. Is. 572. 1888.

Dryopteris cyatheoides C. Chr. Ind. Fil. 66. 1906.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On rocky ledges, along streams, Hawaiian Islands.

ILLUSTRATION: PLATE 10.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; Maui, *Baldwin* C, V; Oahu, *Forbes* BM; *Rock* V.

CYRTOMIUM CARYOTIDEUM (Wall.) Presl, Tent. Pterid. 86. 1836

Aspidium caryotideum Wall. Cat. no. 376. 1828.

Dryopteris caryotidea Underw. in Heller, Minn. Bot. Stud. 1: 779. 1897.

TYPE LOCALITY: Nepal.

DISTRIBUTION: In forests, India, Polynesia, Hawaiian Islands.

ILLUSTRATIONS: Hook. & Grev. Ic. Fil. *pl. 69.* 1826; Presl, Tent. Pterid. *pl. 2. f. 12.* 1836; Brack. Fil. U. S. Expl. Exp. *pl. 16.* 1854; Hook. Garden Ferns *pl. 13.* 1862.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; Maui, *Mann & Brigham 487* N; *Wilkes Expedition* N; Kauai, *Heller 2544* C, N; *Hillebrand* B; *Lydgate* B; Lanai, *Hillebrand* B; Oahu, *Forbes 431* BM; Hawaiian Islands, *Baldwin 59* B, C; *Remy* B; *Miss Sessions* C.

Christensen, following Diels (E. & P. Nat. Pfl. 1^4: 194. 1899), makes *Cyrtomium caryotideum* a synonym of *Polystichum falcatum* (L. f.) Diels. However, as *Polystichum* has free veins and this group has anastomosing veins, they are separated on that character rather than combined on the similarity of their indusia. The type of *Polystichum falcatum* is from Japan. Thunberg, Fl. Jap. 336. *pl. 36.* 1784, describes and figures it, but his figure represents a plant with cordate-falcate leaves not auricled, with scales at the base of the leafstalk. The Hawaiian plant resembles Wallich's specimen at Kew, a tracing from which is in the herbarium of the New York Botanical Garden.

24. TECTARIA Cav. Anal. Hist. Nat. 1: 115. 1799

Rootstock creeping or decumbent; leaves clustered, not articulate, various in form, chartaceous; veins reticulate with free included veinlets; leafstalk purplish brown, smooth above, scaly at the base; sori circular; indusium orbicular, attached at the center.

Type species: *Polypodium trifoliatum* L.

Tectaria cicutaria (L.) comb. nov.

Polypodium cicutarium L. Syst. Nat. ed. 10. **2**: 1326. 1759.
Aspidium cicutarium Sw. Jour. Bot. Schrad. **1800**^{2}: 36. 1801.
Aspidium apifolium Schkuhr, Krypt. Gew. **1**: 198. 1809.
Nephrodium apifolium Hook. & Arn. Bot. Beech. 105. 1832.
Sagenia apiifolia (Schkuhr) J. Sm. Jour. Bot. Hook. **4**: 184. 1841.

TYPE LOCALITY: Jamaica, B. W. I. (?).

DISTRIBUTION: In the tropics, on damp rocks, or in depths of shady forests.

ILLUSTRATIONS: Pluk. Almag. 156. *pl. 296. f. 2.* 1692; Schkuhr, Krypt. Gew. *pl. 56b.* 1809; Hook. & Grev. Ic. Fil. *pl. 202.* 1831.

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; Maui, *Bailey* C; *Baldwin* N; *Robinson 314* V; *328* V; *339* V; Oahu, *Beechey* (ex Herb. Mettenius) C; *Mann & Brigham 189* N; *Robin-*

son 13 V; *18* V; *135* V; *Safford 914* N; *915* N; *916* N; *Wilkes Expedition* N; Kauai, *Heller 2842* C, N; *Hillebrand 60* B; *Knudsen 68* B; Hawaiian Islands, *Baldwin 68* B, C, N; *Hillebrand* (ex herb. Berlin) C; *Lindley* C; *Miss Sessions* C; ex Herb. Underw. C; ex Herb. John Donnell Smith N; *Wilkes Expedition* C, N.

25. NEOTTOPTERIS J. Sm. Jour. Bot. Hook. 3: 409. 1841

A genus of epiphytic ferns, with fleshy, orchid-like roots, found in the forests of tropical Asia, Polynesia, Australia, and Africa. Rootstock erect, short; leaves large, simple, cespitose, sessile or nearly so, spreading, glabrous, entire, arranged spirally with short internodes; veins slender, parallel, close (less than 1 mm. apart), oblique to the midrib, connected by a transverse intramarginal vein at their apices; sori linear, extending from near the midrib ½ to ⅔ the length of the veins in the distal half or two thirds of the leaf.

Type species: *Neottopteris Nidus* (L.) J. Sm.

NEOTTOPTERIS NIDUS (L.) J. Sm.; Hook. & Bauer, Gen. Ferns *pl. 113B.* 1842

Asplenium Nidus L. Sp. Pl. 1079. 1753.
Thamnopteris Nidus Presl, Epim. 68. 1849.

TYPE LOCALITY: Java.

DISTRIBUTION: On trees and on humus soil in forests, usually below 700 m., tropical Asia, Australia, Madagascar, and Polynesia.

ILLUSTRATIONS: Hook. & Bauer, Gen. Ferns *pl. 113B.* 1842; Breyne, Exot. Pl. Cent. *pl. 99.* 1678.

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; Maui, *Bailey* C; Oahu, *Didrichsen 3652* C; *Gaudichaud* B; *Hillebrand* B; *Meyen* B; *Robinson 17* V; *103* V; Kauai, *Heller 205* C; Hawaiian Islands, *Baldwin 30* C; *Mann & Brigham 137* N; *Safford 31* N; *Miss Sessions* C.

26. ASPLENIUM L. Sp. Pl. 1078. 1753

A genus of world-wide distribution, especially well represented in the temperate zones, though including many tropical forms.

Rootstock erect or creeping; leaves non-articulate, usually cespitose; blades simple to quadripinnate, coriaceous to mem-

branaceous; veins free in Hawaiian species; sori linear upon the veins, usually oblique to the midrib or leading vein of the pinna, occasionally parallel with it; indusia attached to veins, opening towards the midrib; sori occasionally athyrioid or diplazioid.

Leafblades simply pinnate.
Pinnae orbicular to rhomboidal or oblong, subentire.
Rootstock creeping; leaves distant. *A. unilaterale.*
Rootstock short, erect; leaves cespitose.
Leafstalk dull green, flexuose.
Pinnae rhomboidal to flabellate, occasionally distant, gradually reduced below. *A. rhomboideum.*
Pinnae ovate-obtuse, approximate, abruptly reduced below. *A. lunulatum.*
Leafstalk dark brown or black, rigid.
Blade chartaceous; sori on veins parallel to the lower margin, opening upwards. *A. monanthes.*
Blade subcoriaceous; sori on secondary veins, indusium opening toward primary vein.
Blade 2.5–10 cm. long; pinnae ovate to suborbicular. *A. Trichomanes.*
Blade 15 cm. long; pinnae oblong. *A. pavonicum.*
Pinnae lanceolate, margin serrate, incised, or lobed.
Leafstalks green.
Pinnae auricled at base. *A. pseudofalcatum.*
Pinnae not auricled at base.
Leafblade coriaceous; basal scales of leafstalk ovate.
Pinnae obtuse at apex; broadly ovate; sorus conterminous with vein; veins obscure. *A. Kaulfussii.*
Pinnae caudate; sorus shorter than vein; veins distinct. *A. kauaiense.*
Leafblade chartaceous; basal scales lanceolate or linear.
Leafblade 30–35 cm. long, oblong-ovate; basal scales of leafstalk lanceolate. *A. enatum.*
Leafblade 20–25 cm. long, oblong-lanceolate; basal scales of leafstalk linear. *A. Hillebrandii.*
Leafstalks brown or steel-blue.
Pinnae serrate or incised.
Pinnae caudate.
Primary veins parallel to the midrib. *A. contiguum.*
Primary veins divergent from the midrib. *A. caudatum.*

Pinnae acuminate. *A. nitidulum.*

Pinnae cut into rhombic lobes.

Leafstalk and midrib paleaceous. *A. horridum.*

Leafstalk and midrib smooth. *A. glabratum.*

Leafblades more than once pinnate.

Blades bipinnatifid to bipinnate, upper basal pinnule auriculate. *A. lobulatum.*

Blades bipinnate to quadripinnate, basal pinnules various.

Blades bipinnate to tripinnatifid.

Blades chartaceous.

Blades under 35 cm. long.

Blades oblong, ultimate divisions flabellate.

Blades 3.75–7 cm. × 12–18 mm. *A. varians.*

Blades 20–30 cm. × 18–45 mm. *A. Macraei.*

Blades lanceolate, ultimate divisions ovate-lanceolate. *A. Lydgatei.*

Blades over 35 cm. long.

Pinnae linear-lanceolate, patent; pinnules obliquely trapezoid-ovate. *A. Goldmannii.*

Pinnae lanceolate, approximate; pinnules rhomboidal, basal pinnules occasionally auriculate. *A. acuminatum.*

Blades coriaceous.

Blades oblong, ultimate divisions obovate or truncate.

Pinnae obliquely rhomboidal, approximate. *A. rhipidoneuron.*

Pinnae ovate oblong, patent.

Blades lanceolate. *A. insiliciium.*

Ultimate divisions flabellate or truncate, pinnae approximate. *A. cuneatum.*

Ultimate divisions ovate-lanceolate, patent. *A. parallelum.*

Blades tripinnate to quadripinnate.

Blades broadly oblong. *A. patens.*

Blades deltoid or deltoid lanceolate.

Blades broadly deltoid, 10–20 cm. long. *A. Adiantum-nigrum.*

Blades deltoid lanceolate, 30 cm. or more long.

Blades membranaceous; ultimate divisions spinulose. *A. vexans.*

Blades thick, chartaceous.

Rachis winged; ultimate divisions spatulate, less than 2 mm. broad. *A. schizophyllum.*

Rachis not winged; ultimate divisions 4 mm. or more broad. *A. sphenotomum.*

ASPLENIUM UNILATERALE Lam. Encyc. **2**: 305. 1786

Asplenium resectum J. E. Sm. Pl. Ic. Ined. 3. *pl. 72.* 1790–91.
Asplenium amoenum Presl, Tent. Pterid. 107. 1836.
Asplenium emargino-dentatum Zenker; Kunze, Linnaea **24**: 263. 1851.

TYPE LOCALITY: Mauritius.

DISTRIBUTION: In wet, shady localities, Mauritius, Japan, China, Polynesia, Hawaiian Islands.

SPECIMENS EXAMINED: Hawaii, *Robinson 622* V; *Wilkes Expedition* N; Maui, *Bailey* C; *Lichtenthaler* N; *Heller 2844* C, N; *Robinson 359* V; *366* V; *380* V; Oahu, *Arnott* N; *Beechey* C; *Mann & Brigham 168* N; *Robinson 72* V; *120* V; *122* V; *184* V; *Safford 918* N; Kaala Mts., *Wilkes Expedition* N; Kauai, *Forbes 439* BM; Hawaiian Is., *Baldwin 37* C, N; *Miss Sessions* C; *Wilkes Expedition* C, N; ex Herb. John Donnell Smith N.

ASPLENIUM RHOMBOIDEUM Brack. Fil. U. S. Expl. Exp. 156. 1854

Asplenium stoloniferum Presl, Rel. Haenk. 1:44. 1825. Not Bory.
Asplenium fragile Presl, Hilleb. Fl. Haw. Is. 589. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: At elevations of 400–700 m., Hawaii and Maui.

ILLUSTRATIONS: Brack. Fil. U. S. Expl. Exp. *pl. 21. f. 2.* 1854; Presl, Rel. Haenk. 1: *pl. 6. f. 4.* 1825.

SPECIMENS EXAMINED: Hawaii, Mauna Kea, *Wilkes Expedition* N; Forest near Cape Lua Pele, *Wilkes Expedition* N; Maui, *Hillebrand* N; Hawaiian Is., *Baldwin* B, C, N; ex Herb. John Donnell Smith N.

A. rhomboideum is closely related to the South American *A. fragile* and to *A. viride* of N. Europe and Canada. It differs from both in the openness of the fronds and flabellate form of the pinnae as well as in size.

Kunze (Klotzsch, Linnaea **13**: 140. 1839) in describing *A. fragile* collected by Ehrenberg in Peru gives the length of the largest fronds as 2 in. He describes the habit as the same as that of *A. viride* and makes *A. castaneum* Schlect. (Linnaea **5**: 611. 1830) and *A. projectum* Kunze (Linnaea **9**: 68. 1834) synonyms. Diels, in E. & P. Nat. Pfl. 1^4: 235. 1899, gives *A. fragile* as a doubtful species, while he gives *A. castaneum* and *A.*

projectum true specific rank. Christensen (Ind. Fil.) gives the same treatment.

ASPLENIUM LUNULATUM Sw. Jour. Bot. Schrad. 1800: 202. 1801

Asplenium erectum Bory, Willd. Sp. Pl. 5: 328. 1810.

TYPE LOCALITY: South Africa.

DISTRIBUTION: Tropical countries.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; *Lichtenthaler* N; Maui, *Bailey* C; *Robinson 720* V; *721* V; Kauai, *Forbes 377* BM; *Heller 2845* C; *Knudsen 147* B; Hawaiian Is., *Baldwin 35* N; *Biddlesome* N.

ASPLENIUM MONANTHES L. Mant. 130. 1767

Asplenium monanthemum Murr. L. Syst. Nat. ed. 13. 785. 1774.
Asplenium Menziesii Hook. & Grev. Ic. Fil. *pl. 100.* 1829.
Asplenium leptophyllum Fée, Mém. Foug. 7. 50. *pl. 14. f. 2.* 1857.

TYPE LOCALITY: Cape of Good Hope.

DISTRIBUTION: At elevations of 900–1,800 m., South America, Northern Africa, the Azores, Madeira Islands, Hawaiian Islands.

ILLUSTRATIONS: J. E. Sm. Pl. Ic. Ined. *pl. 73.* 1790–91; Brack. Fil. U. S. Expl. Exp. *pl. 20. f. 2.* 1854; Fée, Mém. Foug. 7. *pl. 14. f. 2.* 1857; Hook. & Grev. Ic. Fil. *pl. 100.* 1829.

SPECIMENS EXAMINED: Maui, *Bailey* C; *Bishop 77* B; *Hillebrand* B; *Lichtenthaler* N; Kauai, *Knudsen 132* B; Oahu, *Diell* C; Hawaiian Is., *Baldwin 32* B, C; 1838–42; *Wilkes Expedition* N.

In the Berlin Herbarium there are two types of *A. monanthes*, one lax, spreading, with lobed pinnae, proliferous above, the other upright, taller, proliferous from lowest axils of pinnae, yet there is not enough difference to separate them as species.

ASPLENIUM TRICHOMANES L. Sp. Pl. 1080. 1753

Asplenium densum Brack. Fil. U. S. Expl. Exp. 151. 1854.

TYPE LOCALITY: Europe.

DISTRIBUTION: On rocks in temperate regions; on mountain sides in the tropics.

ILLUSTRATIONS: Brack. Fil. U. S. Expl. Exp. *pl. 20. f. 3, 3a.* 1854.

SPECIMENS EXAMINED: Maui, *Bailey* C; *Hillebrand* B; *Finsch 27* B; Oahu, Mt. Kaa, *Macrae* B; Hawaiian Is., *Baldwin* B, C; *Wilkes Expedition* B, C; *Lindley* C.

The difference between *A. densum* Brack. and the European *A. Trichomanes* L. consists in the fewer sori (never more than one row in the Hawaiian plant) and the more prominent wings upon the rachis, which suggests the question whether slight differences between plants widely separated geographically should be regarded as specific.

ASPLENIUM PAVONICUM Brack. Fil. U. S. Expl. Exp. 150. 1854

Asplenium normale Hilleb. Fl. Haw. Is. 588. 1888. Not Don.

TYPE LOCALITY: Saw Mill, Hawaii.

DISTRIBUTION: In moist, shady forests, Hawaiian Islands; rare.

ILLUSTRATION: Brack. U. S. Expl. Exp. *pl. 20. f. 1, 1a, 1b.*

SPECIMENS EXAMINED: Hawaii, *Wilkes 50465* N (type); Kilauea, *Lichtenthaler* N; Maui, *Bailey* C; *Lichtenthaler* N; Kauai, *Forbes 160* BM; *Heller 2771* C, N; *Knudsen 10* B; *Robinson 823* V; Oahu, *Heller 2218* C; *Safford 976* N; *977* N; Hawaiian Is., *Baldwin 33* C; *Lydgate* B; *Macrae* B; *Van Ingen* C; ex Herb. John Donnell Smith N; *Wilkes Expedition* B.

A. pavonicum is very nearly related to *A. normale* Don from Ceylon, but differs in the form of the pinnae and in size.

ASPLENIUM PSEUDO-FALCATUM Hilleb. Fl. Haw. Is. 597. 1888

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; *Robinson 628* V; *620* V; *279* V; *Wilkes Expedition* N; Maui, *Lichtenthaler* C; *Robinson 716* V; *710* V; ex Herb. John Donnell Smith N; Oahu, *Hillebrand* B; *Remy* B; *Robinson 144* V; *173* V; Hawaiian Is., ex Herb. Mt. Holyoke College C.

From the forms of *A. lobulatum* the pinnae of which are little divided, *A. pseudo-falcatum* is distinguished by its chartaceous texture in contrast to the coriaceous texture of *A. lobulatum.*

ASPLENIUM KAULFUSSII Schlect. Adumbr. 29. 1825

Asplenium protensum Kaulf. Enum. 167. 1824. Not Schlect.

Asplenium obtusatum Underw. in Heller, Minn. Bot. Stud. 1: 775. 1897. Not Forst.

TYPE LOCALITY: Oahu.

DISTRIBUTION: Higher forest regions, Oahu, Hawaii.

SPECIMENS EXAMINED: Hawaii, *Remy* B; *Baldwin* B; Oahu, *Anderson* B; *Forbes* BM; *Heller 2361* C; *Day* B; *Macrae* B; Kauai, *Robinson 843* V; Hawaiian Is., *Lydgate* B, C; ex Herb. John Donnell Smith *599* N; *Wilkes Expedition* N.

The sori are usually of the *Asplenium* type but in some cases diplazioid, while in others, the sori borne on adjacent veins face each other.

Asplenium kauaiense (Hilleb.) sp. nov.

Asplenium Mannii var. *kauaiense* Hilleb. Fl. Haw. Is. 595. 1888.

Asplenium obliquum Underw. in Heller, Minn. Bot. Stud. 1: 775. 1897. Not Forst.

TYPE LOCALITY: Kauai.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Kauai, *Knudsen 103* (type) B; *104* B; *105* B; *Heller 2486* C, N; Hawaiian Is., *Wilkes Expedition* N.

ASPLENIUM ENATUM Brack. Fil. U. S. Expl. Exp. 153. 1854

Asplenium lucidum Underw. in Heller, Minn. Bot. Stud. 1: 774. 1897. Not Forst.

TYPE LOCALITY: Kaala Mts., Oahu.

DISTRIBUTION: Hawaiian Islands.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 21. f. 1.* 1854.

SPECIMENS EXAMINED: Oahu, *Wilkes Expedition* N; Maui, *Bailey* C; *Bishop* B; *Lydgate* B, C; *Mann & Brigham 485* N; *Hillebrand* B; Kauai, *Forbes 53* BM; *Heller 2692* C, N; Kauai, *Van Ingen* C; *Robinson 840* V; Oahu, *Day 79* B; *Hillebrand* B; *Lichtenthaler* N; *Safford 871* N; *Wilkes Expedition* C, (type) N; Hawaiian Is., *Baldwin 38* C, N; *Miss Sessions* C; ex Herb. John Donnell Smith *38* N; *39* N; ex Herb. Mt. Holyoke College C.

ASPLENIUM HILLEBRANDII C. Chr. Ind. Fil. 115. 1905

Asplenium Mannii Hilleb. Fl. Haw. Is. 594. 1888. Not Hook.

TYPE LOCALITY: Waianae Range, Oahu.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Oahu, *Hillebrand* B, C; *Safford 917* N; Hawaiian Is., *Miss Sessions* C.

ASPLENIUM CONTIGUUM Kaulf. Enum. 172. 1824

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Hawaii, *Mann & Brigham 160* N; Maui, *Hillebrand* B; *Robinson 325* V; *382* V; *712* V; *Wilkes Expedition* N; *Lichtenthaler* N; Kauai, *Knudsen 140* B; Oahu, *Bartsch 29* N; *Forbes* BM; *Heller 2115* C, N; *Mann & Brigham 156* N; *Safford 902* N; *903* N; *911* N; *Remy* B; *Wilkes Expedition* N; Molokai, *Hillebrand* B; Hawaiian Is., *Baldwin 40* B, C, N; *42* C; *Lindley* C.

ASPLENIUM CAUDATUM Forst. Prod. 80. 1786

Asplenium spathulinum Hilleb. Fl. Haw. Is. 604. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Tropical countries.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 22.* 1854.

SPECIMENS EXAMINED: Maui, *Hillebrand 13* B; *Robinson 632* V; Kauai, *Forbes 636* BM; *Knudsen 130* B; *137* B; *141* B; *142* B; *148* B; *149* B; Hawaiian Is., *Baldwin* B; *Gaudichaud* B.

Hillebrand, Fl. Haw. Is. 604. 1888, separates *Knudsen 141* and *148* as *A. spathulinum* on the basis that the pinnae in these specimens are more deeply incised than in the others. *Robinson 632* V shows both deeply cut and simply serrate leaves on the same plant.

Many of the segments are somewhat diplazioid, because sori arise on both sides of the initial vein and each extends along one of the forks.

ASPLENIUM NITIDULUM Hilleb. Fl. Haw. Is. 601. 1888

TYPE LOCALITY: Kauapali, W. Maui, Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Hillebrand* B (type); *Bailey* C; *Lichtenthaler* N; Oahu, *Heller 2055* C; Hawaiian Is., *Baldwin* N.

This is separated from *A. contiguum* on its firmer character and the acuminate apices of its pinnae in contrast to the lax and often recurving pinnae of the latter.

Heller 2055, though soriferous and apparently typical as to size and form of pinnae, has laciniate leaf blades on each plant that present the same ragged appearance that Hillebrand describes for *A. contiguum* var. *laciniatum*. Some of the specimens are diplazioid.

ASPLENIUM HORRIDUM Kaulf. Enum. 173. 1824

TYPE LOCALITY: Oahu.

DISTRIBUTION: In valleys above 500 m. elevation; South Pacific Islands and Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. 3: *pl. 193*.

SPECIMENS EXAMINED: Hawaii, *Remy* B; *Robinson 204* V; Maui, *Bishop 55* B; Oahu, *Anderson* B; *Forbes* BM; *Hillebrand* B; *Lichtenthaler* N; *Mann & Brigham 58* N; *Hillebrand* B; *Safford 908* N; *Wilkes Expedition* N; Kauai, *Heller 2853* C, N; *Knudsen 116* B; Hawaiian Is., *Baldwin 45* B, C, N; *Gaudichaud* B; *Wilkes Expedition* C, N; *Miss Sessions* C.

Asplenium glabratum sp. nov.

Rootstock short, scaly; leaves cespitose; leafstalk 25–50 cm. long, dull green to steel-blue, naked; blade 35–70 cm. × 11–20 cm., oblong, lanceolate, coriaceous, dull green; pinnae 5–10 cm. × 11–12 mm., oblong-lanceolate, cut into obliquely obovate, sometimes recurving lobes; veins flabellate; sori on the anterior vein in each lobe parallel to the midrib and also on other veins.
Asplenium horridum var. B. Hilleb. Fl. Haw. Is. 604. 1888.
Asplenium horridum Kaulf. var. Underw. in Heller, Minn. Bot. Stud. 1: 774. 1897.

TYPE LOCALITY: Woods of Kahuku and Kahana, Oahu.

DISTRIBUTION: Oahu and Kauai, Hawaiian Islands.

SPECIMENS EXAMINED: Kauai, *Heller 2588* C (type), N; Hawaii, *Robinson 295* V; Oahu, *Hillebrand* B.

This species is distinguished from *A. horridum* Kaulf. by the smoothness and dull steel-blue color of its leafstalk and midrib, and by the greater number of sori which extend along the flabellate veins of the pinnae.

ASPLENIUM LOBULATUM Mett. in Kuhn, Linnaea 36: 100. 1869

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Hawaii, *Mann & Brigham 167* N; *Robinson 612* V; *707* V; *Wilkes Expedition* N; Maui, *Bailey* C; *Robinson 348* V; *371* V; Oahu, *Heller 2115* C, N; *Mann & Brigham 517* N; Oahu, *Robinson 138* V; *146* V; Kauai, *Van Ingen* C; *Miss Sessions* C.

The following specimens are diplazioid in certain pinnules: *Bailey* C; *Van Ingen* C; *Meyen* B; *Miss Sessions* C; *Wilkes Expedition* N.

ASPLENIUM VARIANS Hook. & Grev. Ic. Fil. *pl. 172.* 1830

TYPE LOCALITY: Nepal.

DISTRIBUTION: Japan, China, Ceylon, Africa, Hawaiian Islands.

ILLUSTRATION: Hook. & Grev. Ic. Fil. *pl. 172.* 1829.

SPECIMENS EXAMINED: Maui, *Lichtenthaler* N; *Baldwin 53* B, C, N; ex Herb. John Donnell Smith N.

Hooker and Greville state that this is not mentioned in Wallich's list of the plants in the herbarium of the East India Company, though he collected it at Nepal in 1818 and presented the type specimen to Dr. Hooker at Kew (Ms. Herb. Hook.).

ASPLENIUM MACRAEI Hook. & Grev. Ic. Fil. *pl. 217.* 1831

Asplenium strictum Brack. Fil. U. S. Expl. Exp. 168. 1854.

Asplenium erectum Macraei Hilleb. Fl. Haw. Is. 590. 1888.

Asplenium rhizophyllum Heller, Minn. Bot. Stud. 1: 775. 1897. Not Kunze.

Asplenium lunulatum var. C. Chr. Ind. Fil. 119. 1906.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On ground in open woods, Hawaiian Islands.

ILLUSTRATION: Hook. & Grev. Ic. Fil. *pl. 217.* 1831.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; *Safford 99* N; Oahu, *Heller 2117* C, N; *Hillebrand* B; *Mann & Brigham 173* N; *Macrae* B; *Robinson 136* V; *139* V; *164* V; *Safford 897* N; *Wilkes Expedition* N; Kauai, *Forbes 390* BM; *2764* C, N; *Knudsen 110* B; *133* B; *145* B; *146* B; *148* B; *Lichtenthaler* N; *Wilkes Expedition* N; Hawaiian Islands, *Baldwin 36* C; *Miss Sessions* C; ex Herb. John Donnell Smith N; *Wilkes Expedition* C, N.

Hillebrand's *Asplenium erectum e myriophyllum* doubtless be-

longs here. *Heller 2764*, *Knudsen 145*, *Baldwin 36*, and *Gaudichaud* (B) conform to the *e* type, which has slender, spaced pinnules, while *Heller 2117* and *Heller 2764* have both open and the compact forms of leaf upon the same plant. Occasionally a sorus is diplazioid.

Hillebrand describes *A. erectum* as having a smooth rachis, while *A. Macraei* has a winged rachis.

The original description of *A. lunulatum* (Sw. Jour. Bot. Schrad. 1800[2]: 52. 1801) gives the pinnae as rhomboid, ovate, crenulate; the African specimens are simply pinnate, the pinnae being auricled.

ASPLENIUM LYDGATEI Hilleb. Fl. Haw. Is. 596. 1888

TYPE LOCALITY: Niu, Oahu.

DISTRIBUTION: Known from type locality only.

The plant is represented at Berlin by two specimens collected by Lydgate in 1871.

Asplenium Goldmannii Underw. in herb., nom. nov.

Tarachia polyphylla Presl, Epim. 83. 1849.

Asplenium polyphyllum Hilleb. Fl. Haw. Is. 607. 1888. Not Bert.

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

ILLUSTRATION: Mett. Aspl. *pl. 5. f. 23.* 1859.

SPECIMENS EXAMINED: Oahu, *Baldwin 51a* B, C; *Forbes* BM; *Wilkes Expedition* N; *Lydgate* B; Hawaiian Islands (collector unknown) C.

ASPLENIUM ACUMINATUM Hook. & Arn. Bot. Beech. 106. 1832

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Bailey* C; *Baldwin 51b* B; *51c* B; *Hillebrand* C; *Robinson 376* V; Oahu, *Forbes* BM; *Hillebrand* B; *Robinson 149* V; *151* V; *186* V; *Wilkes Expedition* N; *Lichtenthaler* N; Kauai, *Forbes 85* BM; *140* BM; *Robinson 428* V; *479* V; *488* V; *497* V; *702* V; Hawaiian Islands, *Baldwin 51* C, N, C; *Mann & Brigham 494* N; *Wilkes Expedition* N; ex Herb. John Donnell Smith N.

Asplenium rhipidoneuron nom. nov.

Asplenium furcatum Hilleb. Fl. Haw. Is. 604. 1888. Not Thunb.

TYPE LOCALITY: Haleakala, Maui.

DISTRIBUTION: Hawaiian Islands.

ILLUSTRATION: Hook. & Grev. Ic. Fil. *pl. 189.* 1831.

SPECIMENS EXAMINED: Hawaii, *Baldwin 50* B, C, N; *Wilkes Expedition* N; Maui, *Bailey* C; *Baldwin 44* (type) B, C, N; *Robinson 353* V; *392* V; *796* V; *Wilkes Expedition* N; Oahu, *Mann & Brigham 261* N; *Wilkes Expedition* N; Kauai, *Forbes 58* BM; *Heller 2872* C, N; *Van Ingen* C; Hawaiian Islands, *Baldwin 49* C; *Wilkes Expedition* C.

A. rhipidoneuron may be separated into two forms.

Pinnae under 4 cm. long, rhombic.
Pinnae 6–15 cm. long, acuminate.

This will scarcely separate them as two species, but it is interesting as it suggests the possible crossing of *A. lobulatum* and *A. cuneatum.*

ASPLENIUM INSITICIUM Brack. Fil. U. S. Expl. Exp. 161. 1854

Asplenium cristatum Brack. Fil. U. S. Expl. Exp. 163. 1854. Not Lam.

TYPE LOCALITY: Hawaiian Is., in forests.

DISTRIBUTION: Hawaiian Is., Philippine Is., New Caledonia.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 22. f. 2.* 1854.

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition* N; *Mann & Brigham* N; Maui, *Bailey* C; *Hillebrand* B; *Lichtenthaler* N; Waiopua, *Lichtenthaler* N; Oahu, *Baldwin* B; *Forbes* BM; *Heller 2310* C, N; *Hillebrand* B; Nuuanu, *Robinson 142* V; *Hillebrand* B; Hawaiian Is., *Baldwin 41* C; *43* C, N; *Wilkes Expedition* N; ex Herb. John Donnell Smith N.

A. insiticium Brack. is a more delicate fern than *A. lobulatum.*

The following specimens are diplazioid: *Asplenium insiticium grandipinnatum* Hillebrand B; *Asplenium insiticium pseudonitidum* Hillebrand B.

ASPLENIUM CUNEATUM Lam. Encyc. 2: 309. 1786

TYPE LOCALITY: Jamaica, B. W. I.

DISTRIBUTION: West Indies, Philippine, Fiji, Samoan, and Hawaiian Islands.

ILLUSTRATIONS: Sloane, Hist. Jam. 1: 46. *f. 2.* 1707. Brack. Fil. U. S. Expl. Exp. *pl. 21.* 1854.

SPECIMENS EXAMINED: Maui, *Robinson 344* V; *702* V; Kauai, *Heller 2865* C, N; ex Herb. John Donnell Smith N.

This differs from *A. insiticium* in texture and color and is smaller than the average specimen of the latter, though their dimensions overlap.

ASPLENIUM PARALLELUM Baker, Hook. & Baker, Syn. Fil. 486. 1874

Asplenium bipinnatum Hilleb. Fl. Haw. Is. 595. 1888.

TYPE LOCALITY: Niu, Oahu.

DISTRIBUTION: Known from type locality only.

SPECIMENS EXAMINED: Hillebrand B.

This plant is represented by one sheet labelled *Asplenium flaccidum* which is placed with *Asplenium Lydgatei*, at Berlin. It differs from *A. Lydgatei* in being more sturdy in habit and firmer in texture.

ASPLENIUM PATENS Kaulf. Enum. 175. 1824. Not Hook. & Arn. Not Gaud.

TYPE LOCALITY: Oahu.

DISTRIBUTION: Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. 3. *pl. 203.* 1860.

SPECIMENS EXAMINED: Oahu, *Hillebrand* B; Maui, *Hillebrand* B, K; *Lydgate B.*

This rare species resembles *A. cuneatum* in habit in spite of its larger size and tripinnate divisions.

ASPLENIUM ADIANTUM-NIGRUM L. Sp. Pl. 1081. 1753

A. patens Gaud. Voy. Freyc. Bot. 320. 1828. Not Kaulf.

TYPE LOCALITY: Southern Europe.

DISTRIBUTION: Tropical countries.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; *Mann &*

Brigham 259 N; District of Waimea, *Wilkes Expedition* N; Mauna Kea, *Wilkes Expedition* N; Mauna Loa, *Wilkes Expedition* N; Maui, *Hillebrand* B; Haleakala, *Hillebrand* B; *Finsch 8* B; *Wilkes Expedition* N; *Bailey* C; Kauai, *Knudsen* B; *Wilkes Expedition* N; Hawaiian Islands, *Baldwin 48* B, C, N, V; *Gaudichaud* B; *Wilkes Expedition* B, C; *Douglas* B; *Hillebrand* B; ex Herb. John Donnell Smith N.

Gaudichaud's specimen in the Berlin Herbarium is labelled "Forma acutum Bory, var. Onopteris L.," but the plant is not distinguishable by dentation or by other characteristics from other specimens of *A. Adiantum-nigrum*.

ASPLENIUM VEXANS Heller, Minn. Bot. Stud. 1: 776. 1897

TYPE LOCALITY: Slopes of Konahuanui, above Manoa, Oahu.
DISTRIBUTION: Hawaiian Islands.
SPECIMENS EXAMINED: Oahu, *Heller 2058* (type) C; *Robinson* V; *Baldwin* V.

ASPLENIUM SCHIZOPHYLLUM C. Ch. Ind. Fil. 131. 1905. Not Sw.

A. dissectum Brack. Fil. U. S. Expl. Exp. 170. 1854. Not Sw.
TYPE LOCALITY: Hawaii.
DISTRIBUTION: On ground and on trees, Hawaiian Islands.
ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 24*. 1854.
SPECIMENS EXAMINED: Hawaii, *Baldwin 51d* B, C; *Hillebrand* B, C; *Lydgate* B; Maui, *Hillebrand* B; Oahu, *Wilkes Expedition* N; Kauai, *Forbes 361* BM; *Heller 2765* C, N; *Knudsen 113, 115* B; *Johnson* B; Hawaiian Islands, *Baldwin 49* N; *Wilkes Expedition* N.

ASPLENIUM SPHENOTOMUM Hilleb. Fl. Haw. Is. 599. 1888

TYPE LOCALITY: Hawaiian Islands.
DISTRIBUTION: In forests at 1,300–1,600 m. elevation, Hawaiian Islands.
SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; Maui, *Baldwin 52* B; Kauai, *Forbes 339* BM; *420* BM; *Knudsen 108* B; *117* B; Hawaiian Islands, *Baldwin 52* N.

SPECIES INQUIRENDAE

ASPLENIUM PELLUCIDUM Lam. Encyc. 2: 305. 1786

TYPE LOCALITY unknown.
DISTRIBUTION: Malaysia-Polynesia.
SPECIMENS EXAMINED: Ex Herb. Kunth; *Meyen* B.

One specimen with auricled pinnae 52-jugate, and corresponding in other respects to *A. pellucidum* Lam. is in the Berlin Herbarium and was originally in Kunth's Herbarium given by Dr. Meyen in 1833. The specimen is no doubt correctly named but correctness of the locality seems doubtful.

ASPLENIUM MEIOTOMUM Hilleb. Fl. Haw. Is. 596. 1888

TYPE LOCALITY: Wailupe, Oahu.
DISTRIBUTION: Known from type locality only.
SPECIMENS EXAMINED: *Hillebrand* B.

This is represented by a single sterile specimen at Berlin, but Hillebrand's description proves that this is not his entire collection of the plant. It may be a teratological form.

ASPLENIUM KNUDSENII Hilleb. Fl. Haw. Is. 601. 1888

No specimen so labelled or corresponding to Hillebrand's description was found in the Berlin Herbarium.

27. ATHYRIUM Roth, Mag. Bot. Roem. & Ust. 2[1]: 105. 1799

Rootstock short, suberect; leafstalks non-articulate, basal scales usually thin-walled; blades thin, herbaceous, 1–3-pinnate; veins free; vascular bundles of leafstalk in two strands at base, uniting above; sori linear or curving across the vein, or roundish at the end of a vein; indusia corresponding with the sorus in shape, or rarely absent.

Leafblades bipinnatifid.
- Sori on distal portion of veins but not protruding beyond margin of lobe. *A. deparioides.*
- Sori protruding beyond the margin of the lobe, in some cases apparently stipitate. *A. proliferum.*

Leafblades tripinnate to quadripinnate.
- Sori medial upon veins; ultimate divisions of pinnule oblong. *A. Poiretianum.*
- Sori along distal portions of veins; ultimate divisions of pinnule linear. *A. Baldwinii.*

ATHYRIUM DEPARIOIDES (Brack.) Christ, p. p. Farnkr. Erde 223. 1897

[Excl. description and figures]

Asplenium deparioides Brack. Fil. U. S. Expl. Exp. 172. 1854
Athyrium proliferum C. Chr. p. p. Ind. Fil. 145. 1905.

TYPE LOCALITY: Kaala Mts., Oahu.

DISTRIBUTION: Hawaiian Islands.

SPECIMENS EXAMINED: Oahu, *Baldwin* B; *Baldwin 77* B; *Forbes* BM; *Hillebrand* B; *Lydgate* B; Kauai, *Forbes 32* BM; *Forbes 215* BM; *Forbes 238* BM; *Heller 2303* C; *Heller 2690* C; *Baldwin 47b* C; Hawaiian Is., *Baldwin 47* C.

ATHYRIUM PROLIFERUM (Kaulf.) C. Chr. p. p. 145. 1905

Dicksonia prolifera Kaulf. Enum. 225. 1824.
Deparia Macraei Hook. & Grev. Ic. Fil. *pl. 154.* 1829.
Cibotium proliferum Presl, Tent. Pterid. 69. 1836.
Asplenium deparioides var. *y*, Hilleb. Fl. Haw. Is. 615. 1888.
Athyrium deparioides Christ, p. p. Farnk. Erde 223. 1897.
Deparia triangularis Underw. in Heller, Minn. Bot. Stud. 1: 778. 1897.

TYPE LOCALITY: Oahu.

DISTRIBUTION: In wet woods, 300–600 m. elevation, Hawaiian Islands.

ILLUSTRATIONS: Hook. & Grev. Ic. Fil. *pl. 154.* 1829; Christ; Farnk. Erde 223. 1897.

SPECIMENS EXAMINED: Oahu, *Baldwin* B; *Beechey* C; *Brackenridge* N; *Forbes* BM; *Lichtenthaler* N; Kauai, *Heller 2740* C, *Heller 2057* C.

ATHYRIUM POIRETIANUM (Gaud.) Presl, Tent. Pterid. 98. 1836

Asplenium Poiretianum Gaud. Voy. Freyc. Bot. 321. *pl. 13.* 1832.
Allantodia scandicinum Kaulf. Enum. 179. 1836.
Asplenium scandicinum Underw. in Heller, Minn. Bot. Stud. 1: 775. 1897. Not Presl.

TYPE LOCALITY: Oahu.

DISTRIBUTION: In wet forests, at altitudes of 200–300 m., Hawaiian Islands.

ILLUSTRATION: Gaud. Voy. Freyc. Bot. *pl. 13.* 1832.

SPECIMENS EXAMINED: Hawaii, Robinson *616* V; *625* V; Maui, *Bailey* C; *Finsch* B; *Hillebrand* B; *Robinson 715* V; Oahu, *Chamisso* B; *Diell* C; *Forbes* BM; *Hillebrand 27* B; *Macrae* B; *Meyen* B; Kauai, *Heller 2623* C; *Hillebrand 118a* B; Hawaiian Is., *Baldwin 53* B, C; *Gaudichaud* (type) B; *Miss Sessions* C; *Wilkes Expedition* C.

ATHYRIUM BALDWINII (Hilleb.) C. Chr. Ind. Fil. 140. 1905

Asplenium Baldwinii Hilleb. Fl. Haw. Is. 618. 1888.

TYPE LOCALITY: Kauai.

DISTRIBUTION: High altitudes, Kauai.

SPECIMENS EXAMINED: Kauai, *Bailey* C; *Baldwin 54* (type) B, C, K; *Forbes 125* BM; *240* BM; *Robinson 402* V; *426* V; *458* V; *461* V; *464* V.

The sori are subapical in this species and a fibrillose scale appears at the base of almost every pinna, while the sori of *A. Poiretianum* are typically medial or proximal upon the veins.

28. DIPLAZIUM Sw. Jour. Bot. Schrad. **1800**[2]: 61. 1801

Rootstock short, creeping or suberect; leafblades simple to quadripinnatifid; basal scales of leafstalk clathrate, with or without glands; vascular bundles two at the base of leafstalk uniting above; veins free, once to several times forked; sori linear, indusiate, often double, the indusium opening as in *Asplenium*.

Type species: *Diplazium plantaginifolium* (L.) Sw.

The Hawaiian species of *Diplazium* form a very natural group, more firm in texture and coarser in habit than the species of *Athyrium*, hence it seems better on account of the limitations of this paper to follow Diels (Eng. & Prantl, Nat. Pflanzenfam. **1**[4]: 224. 1902) than to place these plants in the genus *Athyrium*, following Milde (Bot. Zeit. **24**: 373. 1866) and Copeland (Philipp. Jour. Sci. **3**: (Bot.) 285. 1908).

Leaves pinnate; rootstock erect or creeping; leafstalks more or less paleaceous at base, with non-glandular scales.

Rootstock erect; leafstalks stout, dull green, dark brown in drying; basal scales few, light brown; leafblade ovate-lanceolate, 15–30 cm. long, membranous; middle pinnae linear-lanceolate, 12.5–15 cm. × 7–22 mm.; basal pinnae reduced, the lowest auricled. ***D. marginale.***

Rootstock creeping; leafstalks slender, stramineous; basal scales dark brown.

Basal scales of leafstalks persistent, numerous; leafblade 45–75 cm. long; middle pinnae linear-lanceolate, falcate; basal pinnae reduced. *D. Fenzlianum.*

Basal scales of leafstalk few, caducous; leafblade 15–30 cm. long; middle pinnae oblong-lanceolate, truncate at the base and parallel to the rachis above, oblique below; basal pinnae not reduced. *D. molokaiense.*

Leaves bipinnate to tripinnate; rootstock creeping; leafstalks paleaceous with glandular scales at base when young, glabrate with age.

Leafblade deltoid or ovate-deltoid, light green, deeply tripinnatifid; pinnae oblong-lanceolate; lower pinnae 5–7.5 cm. distant; pinnules lanceolate. *D. Arnottii.*

Leafblade ovate-oblong, dark green, tripinnate; lower pinnae 12.5–15 cm. distant; pinnules oblong-lanceolate. *D. sandwichianum.*

DIPLAZIUM MARGINALE (Hilleb.) C. Chr. Ind. Fil. 235. 1905

Asplenium marginale Hilleb. Fl. Haw. Is. 613. 1888.

TYPE LOCALITY: Molokai.

DISTRIBUTION: Lower forests, Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Lydgate* B; Molokai, *Hillebrand* (type) B; Oahu, *Baldwin 47a* B; *47b* B; Kauai, *Knudsen 151* B.

DIPLAZIUM FENZLIANUM (Luers.) C. Chr. Ind. Fil. 232. 1905

Asplenium Fenzlianum Luerssen in Wawra, Flora 58: 434. 1875.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: In isolated localities, Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Bailey* C; Oahu, *Baldwin* B; *Hillebrand* B; *Lydgate* B; Molokai, *Hillebrand* B; Hawaiian Is., *Hillebrand* B.

Diplazium molokaiense nom. nov.

Asplenium arboreum Hilleb. Fl. Haw. Is. 609. 1888. Not Willd.

TYPE LOCALITY: Molokai, Hawaiian Islands.

DISTRIBUTION: In wet gulches, Hawaiian Islands.

SPECIMENS EXAMINED: Molokai, *Baldwin 46* B; *Hillebrand* (type) B; Oahu, *Baldwin* B; Kauai, *Forbes 438* BM; *Knudsen 102* B.

DIPLAZIUM ARNOTTII Brack. Fil. U. S. Expl. Exp. 144. 1854

Asplenium diplazioides Hook. & Arn. Bot. Beech. 107. 1832. Not Bory.

Asplenium Arnottii Baker in Hook. & Baker, Syn. Fil. 240. 1867.

Athyrium Arnottii Milde, Bot. Zeit. **28**: 371. 1870.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Lower forests, Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Bailey* C; Molokai, *Hillebrand* B; Oahu, *Beechey* C; *Beratz* B; *Forbes* BM; *Heller 2900* C; *Hillebrand* B; Kauai, *Johnson* B; Hawaiian Is., *Baldwin 55* C; *56* B, C; *57* C; *Mrs. Gulick* C; ex Herb. Kewensis C.

Though the rootstock is prostrate, this fern has almost the appearance of an arborescent form, the leaves reaching a height of from five to six feet.

The Hawaiians prize the tips of the young fronds as a salad.

DIPLAZIUM SANDWICHIANUM (Presl) Diels, in E. & P. Nat. Pflanzenfam. **1**[4]: 228. 1899

Athyrium sandwichianum Presl, Tent. Pterid. 98. 1836.

Asplenium sandwichianum Hook. Sp. Fil. **3**: 225. 1860.

Asplenium brevisorum Baker, in Hook. & Baker, Syn. Fil. Ed. 2. 228. 1874.

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: Hawaiian Islands, Peru.

SPECIMENS EXAMINED: Hawaii, *Beratz* B; *Robinson 620* V; Maui, *Hillebrand* B; *Robinson 386* V; Molokai, *Hillebrand* B; Oahu, *Diell* C; *Forbes* BM; *Heller 2073* C; *Macrae* C; *Meyen* B (cotype); *Robinson 148* V; *156* V; *160* V; Hawaiian Is., *Baldwin* B; ex Herb. Mt. Holyoke College C; *Wilkes Expedition* C.

SPECIES INQUIRENDA

DIPLAZIUM SANDWICHENSE Presl, Epim. 85. 1850–52

From Presl's description this seems to be a form very closely related to *Diplazium molokaiense*, differing from it in the deeper cutting of the lobes and the greater length of the auricle.

Meyen's type is doubtless still in Presl's Herbarium in the Bohemian University at Prague. There seems to have been no further collection of the plant.

29. SADLERIA Kaulf. Enum. 162. 1824

Sadleria, an endemic Hawaiian genus, is frequently found as a pioneer on disintegrating lava rock. It differs conspicuously in

its greater size, rigidity, and the number of its scales, from *Blechnum*, with which Brackenridge and Gaudichaud united it on the basis of the similarity of its sori.

Caudex erect, often arborescent, more or less clothed with scales, or "pulu"; leaves bipinnatifid to bipinnate, 60–180 cm. long in arborescent species, 25–50 cm. in herbaceous forms, usually coriaceous; sori linear upon the intercostal arches on either side of, and parallel to, the midrib of the pinnule, covered by a coriaceous indusium; sporangia short-stalked.

Type species: *Sadleria cyatheoides* Kaulf.

Caudex arborescent, 60–300 cm. in height.
- Leafstalk scaly at base, naked or slightly furfuraceous above; sori usually extending nearly the length of the segment.
  - Leafstalk 60–90 cm. long, sulcate, densely clothed at base with light brown scales, 3–4 cm. × 5 mm., slightly chaffy above; blades chartaceous to subcoriaceous, furfuraceous when young, nearly glabrate when mature, oblong-lanceolate, 150–200 cm. long, bipinnate; pinnae linear, 30–60 cm. × 4–7.5 cm.; pinnules 3 mm. apart. *S. Souleytiana.*
  - Leafstalk 30–60 cm. long, not sulcate, paleaceous at the base with scales 4–5 cm. × 3 mm., naked above; blades coriaceous, glabrate, ovate-oblong, 60–90 cm. long, bipinnatifid; pinnae linear-lanceolate, 15–20 cm. × 1.5–2 cm.; segments of pinnae 2 mm. apart. *S. cyatheoides.*
- Leafstalk scaly throughout, 20–45 cm. long, sulcate; basal scales ribbed, and revolute, upper scales ribless, chaffy; blades coriaceous, oblong, acuminate, 45–60 cm. long, bipinnatifid; pinnae oblong, falcate, 10–16 cm. × 15 mm., chaffy along the midrib; sori usually not as long as the segment, often less than half as long. *S. Hillebrandii.*

Caudex not arborescent, 2–15 cm. in height; leafstalk densely paleaceous as are midribs and costae.
- Leafstalk 15–25 cm. long; scales dark brown, 10–15 cm. long; blades coriaceous, oblong-lanceolate, 25–50 cm. long, pinnae 5–10 cm. × 12–25 mm.; pinnules crowded; margins crenulate. *S. polystichoides.*
- Leafstalk 12–15 cm. long; scales reddish brown, 6–10 cm. long; blades subcoriaceous, ovate-lanceolate, 28–30 cm. long; pinnae 2–4 cm. × 0.75–1 cm., reduced below, not crowded; margins entire. *S. unisora.*

SADLERIA SOULEYTIANA (Gaud.) Moore, Ind. Fil. 26. 1857

Blechnum Souleytianum Gaud. Voy. Bonite Bot. *pl. 2. f. 7, 8; pl. 134.* 1846–49.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Common in deep wet woods at high elevations Hawaiian Islands.

ILLUSTRATIONS: Gaud. Voy. Bonite Bot. *pl. 2. f. 7, 8. pl. 134.* 1846–49.

SPECIMENS EXAMINED: Maui, *Bailey* C; Kauai, *Heller 2807* C; N; Oahu, *Forbes* BM; *Hillebrand* B; Lanai, *Hillebrand* B; Hawaiian Islands, *Baldwin 24* C; N.

SADLERIA CYATHEOIDES Kaulf. Enum. 162. 1824

Blechnum Fontanesianum Gaud. Voy. Freyc. Bot. 397. *pl. 15.*
Sadleria pallida Hook. & Arn. Bot. Beech. 75. 1832.
Blechnum pallidum Brack. Fil. U. S. Expl. Exp. 133, in part, 1854.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Lower elevations, Hawaiian Islands and Sumatra.

ILLUSTRATION: Gaud. Voy. Freyc. Bot. *pl. 15.*

SPECIMENS EXAMINED: Hawaii, *Wilkes Expedition 12* C, N; *13* C, N; Maui, *Bailey* C; Oahu, *Chamisso* B; *Freycinet* K; *Gaudichaud* B; *Hillebrand* B; *Lichtenthaler* N; *Macrae* C; *Mann & Brigham 188* N; *Safford 866* N; *867* N; *868* N; ex Herb. Copeland N; Kauai, *Forbes 40* BM; Hawaiian Islands, *Baldwin 23* B, N; *Miss Sessions* C; ex Herb. John Donnell Smith N.

Chamisso's type in the Berlin herbarium consists of two sheets: (1) Leafstalk 15 cm. long with rigid scales at base, blade 18-jugate, 23 cm. wide; (2) fragment without apex, 16-jugate; slightly wider.

Sadleria Hillebrandii nom. nov.

Sadleria pallida Hilleb. Fl. Haw. Is. 582. 1888. Not Hook. & Arn. Bot. Beech. 75. 1832.
Blechnum pallidum Brack. Fil. U. S. Expl. Exp. 133, in part. 1854.

TYPE LOCALITY: Kauai, *Hillebrand 80* (Herb. Kgl. Bot. Gart. Berlin).

DISTRIBUTION: In dry, exposed places, Hawaiian Islands.

ILLUSTRATION: PLATE 11.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; Maui, *Bailey* C; Oahu, *Hillebrand 83* B; *Robinson 14* V; *19* V; Kauai, *Hillebrand 80* (type) B; *Heller 2866* C, N.

Sadleria pallida Hook. & Arn. proves to be a synonym of

Sadleria cyatheoides Kaulf. The plants confused under this name by Brackenridge, Hillebrand, and most later writers form a distinct species, here named for Hillebrand, since he has most fully described it.

This species is one of the first to gain a foothold upon the lava in the floors of the old craters and is very resistant to dry winds on exposed bluffs.

SADLERIA POLYSTICHOIDES (Brack.) Heller, Minn. Bot. Stud. 1: 788. 1897

Blechnum squarrosum Gaud. Voy. Bonite Bot. *pl. 2. f. 1, 6.* 1846–49. Without description.

Blechnum polystichoides Brack. Fil. U. S. Expl. Exp. 134. 1854.

Sadleria squarrosa Hilleb. Fl. Haw. Is. 582. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: In forests on lower slopes of mountains, Hawaiian Islands.

ILLUSTRATIONS: Gaud. Voy. Bonite Bot. *pl. 2. f. 1, 6.* 1846–49.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; *Wilkes Expedition* N; Oahu, *Forbes* BM; *Hillebrand* B; *Lydgate* B; *Heller 2392* C, N; Molokai, *Hillebrand* B; Kauai, *Forbes 216* BM; Hawaiian Islands, *Gaudichaud* B; *Baldwin 25* B, C, N.

Sadleria unisora (Baker) comb. nov.

Polypodium unisorum Baker; Hook. & Bak. Syn. Fil. 307. 1867.

Gymnogramme sadlerioides Underw. in Heller, Minn. Bot. Stud. 1: 781. 1897.

Sadleria squarrosa var. *depauperata* Hilleb. Fl. Haw. Is. 583. 1888.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: On rocky walls of high plateaus, Hawaiian Islands.

ILLUSTRATIONS: Underw. in Heller, Minn. Bot. Stud. 1: *pl. 43.* 1897. PLATE 12.

SPECIMENS EXAMINED: Kauai, *Hillebrand* B; *Forbes 445* BM; *Heller 2863* C; N.

This is undoubtedly a valid species, rather than an ecological "variety" of *S. polystichoides*, as it has been termed by Hillebrand (Hilleb. Fl. Haw. Is. 583. 1888), for true *S. polystichoides* grows in

the neighborhood of Kilauea, under conditions apparently as xerophytic as those under which *S. unisora* is found.

30. DOODIA R. Br. Prod. Fl. N. Holl. 151. 1810

Rootstock short, oblique; leaves clustered, pinnatifid to pinnate, coriaceous; leafstalk scaly; veins connected by one or more arches parallel to the midrib; sori oblong or slightly curved, in one or more rows parallel to the midrib; indusium membranaceous, opening toward the midrib.

Type species: *Doodia aspera* R. Br.

DOODIA KUNTHIANA Gaud. Voy. Freyc. Bot. 401. 1829

Doodia media Hilleb. Fl. Haw. Is. 584. 1888. Not R. Br.
Doodia media var. C. Chr. Ind. Fil. 242. 1905.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Common on banks of streams or in wet woods at 500–900 m. altitude; Hawaiian Islands.

ILLUSTRATION: Gaud. Voy. Freyc. Bot. *pl. 14.*

SPECIMENS EXAMINED: Hawaii, *Robinson 230* V; *241* V; Maui, *Robinson 305* V; *318* V; *350* V; Oahu, *Baldwin* N; *Macrae* B; *Robinson 74* V; *Safford 895* N; *Wilkes Expedition* N; Kauai, *Forbes* BM; *252* BM; *Heller 2601* C, N; *Van Ingen* C; *Robinson 803* V; *809* V; Hawaiian Islands, *Baldwin 26* B, C, N; *Baldwin 27* B, C; *Gaudichaud* B, C; *Miss Sessions* C; ex Herb. J. Donnell Smith N.

This species has been confused by Hillebrand and others with *D. media* R. Br. (type from Australia), the lower pinnae of which become reduced to small triangular auricles. It is safer to maintain the species as distinct under Gaudichaud's name. An allied species with widely spaced pinnae, collected in the Fiji Islands by Capt. Wilkes, is mentioned by Brackenridge (Fil. U. S. Expl. Exp. 138. 1854) as a "var. B."

Mr. C. N. Forbes's *D. Kunthiana* var. *depauperata* (*252* BM), collected "on rocky ledges along the main Wahiawa," is so much smaller than the other plants of *D. Kunthiana* as to have an entirely different appearance. However, as to the form of the leaf, pinnate below, pinnatifid in the upper half, and the form of the linear-lanceolate scales, they are similar. These small plants are

fine fruiting condition.

The development of the embryo-sac of Arisaema triphyllum

F. L. Pickett

(WITH PLATES 13 AND 14)

The development of the embryo-sac of *Arisaema triphyllum* was first studied by Strasburger (1) in 1879, and later by Mottier (2), who published his observations in 1892. Campbell (3, 4) in his studies on the Araceae has referred to the findings of Mottier and used them as a basis for comparison. Gow (5), in his introduction to the study of the embryogeny of *Arisaema triphyllum*, reviewed the development of the embryo-sac, confirmed the findings of the second study mentioned above, and added observations of the division of a primary archesporial cell to form embryo-sac initials. The writer has been able, after the examination of several hundred ovules, to verify most of the stages in the embryo-sac development as set forth in the above-mentioned articles; but has found some notable points of difference touching the formation of megaspores from the primary archesporial cell. On the other hand the writer has found that in some respects the development of *Arisaema triphyllum* agrees very closely with that of *Symplocarpus foetidus* as shown by Rosendahl (6) in 1909.

The material for the present study was collected in proper season through four years, 1909–12. The various stages were secured from as many habitat conditions as possible. All fixing was done in the field or immediately after the return to the laboratory. Parts of young spikes and separate pistillate flowers of older spikes were fixed, some in strong chrome-acetic acid mixture, and others in chrome-osmic-acetic acid mixture, for 24–30 hours, then washed in running water for 24 hours, and finally gradually dehydrated. The blackening from osmic acid was in some cases removed by treatment of the whole specimens with hydrogen peroxide; but this resulted in considerable shrinkage, so that the specimens were of very little value. The sections were stained with safranin-gentian violet-orange G, with occasional special staining of cell walls with Bismarck brown.

OVULE AND MEGASPORE MOTHER CELL

The ovules occur in groups of two to six arising from the basal placenta in each ovary. As it first appears, each ovule is a rounded conical mass of cells covered by a clearly marked epidermal layer, but otherwise undifferentiated (FIG. 4). Soon after the ovule has reached the stage shown in FIG. 4, or about the time of the appearance of the inner integument, the primary archesporial cell, or megaspore mother cell or cells, may be found at the apex of the nucellus beneath the epidermis. These cells are hypodermal in origin, and are clearly differentiated from surrounding cells by their greater size, denser cytoplasm, and larger nuclei. The time of the differentiation of the sporogenous cells is only approximately the same as that of the development of the first integument as will be seen by a comparison of FIG. 1, 2, 3, 6, 8. FIG. 1 and 2 show two and three clearly differentiated megaspore mother cells, and FIG. 6 one such cell with complete periclinal divisions of the epidermal cells, while the integument in each of these ovules shows less growth than in FIG. 3 where no such cell can be with certainty distinguished. From one to four megaspore mother cells have been observed in a single nucellus (FIG. 1, 7, 8, 9, 11). These are usually in the hypodermal layer at first, although in a few instances some were beneath that (FIG. 2, 11, 19). The cells in FIG. 11 and 19 have been removed from the surface by periclinal division of epidermal cells. In every specimen examined the megaspore mother cells were contiguous, but in no case was there found direct evidence that they had been formed by a division of a primary archesporial cell as suggested by Mottier (2, p. 259), and by Gow (5, p. 40). The position of the cells in FIG. 19 and of the two cells at the left in FIG. 11 indicates that such an origin is possible; but the failure to find other than very rare cases of nuclear activity in cells which have not arisen by the division of epidermal cells discredits the probability of such an origin. The only form of nuclear activity found in clearly differentiated sporogenous cells was the synaptic or later stages in the tetrad division. The fact that in different ovules showing the same general structure, more than one megaspore mother cell may be found, suggests the origin of such multiple sporogenous cells by simultaneous differentiation from hypodermal cells (see FIG. 1, 2, 8). That

the division of a primary archesporial cell to form two or more megaspore mother cells or embryo-sac initials is not universal, or even regular, is proven by the presence of many ovules showing the development of but one tetrad of potential megaspores or but one embryo-sac, without evidence of other crushed or damaged initial cells (FIG. 17, 18, 22, 23, 24). Fig. 7, 9, 13 show cross sections of the nucellus with the megaspore mother cells variously arranged.

THE TETRAD OF MEGASPORES

As the inner integument grows and incloses the nucellus, and the outer integument appears, the megaspore mother cells increase in size, and the epidermal cells of the nucellus undergo periclinal division. This periclinal division, shown at its beginning in FIG. 2 and 5, takes place more rapidly at the apex, sometimes forming a layer of four cells above the megaspore initials (FIG. 16, 18, 22). The division of lateral cells is also irregular and results in a final covering one to three layers of cells in thickness (FIG. 10, 11, 24). During these changes in the size and form of the ovule, the megaspore mother cells increase rapidly in size, becoming somewhat broader and much longer than the surrounding cells. Nuclear changes are also evident, and by the time the outer integument is well started most of the nuclei of the megaspore mother cells show either synapsis or closely related conditions preparatory to the first tetrad division (FIG. 7, 9, 12, 14, 16). The first division of the megaspore mother cell nucleus is quickly followed by the second, the result being a tetrad of potential megaspores (FIG. 18). The first division is usually followed by the formation of a cell wall as in FIG. 22 and 24, but this is not always the case, as is shown in FIG. 23. These divisions are usually transverse as shown in the cell at the left in FIG. 16, in the middle cell of FIG. 15*a*, and in FIG. 24. The resulting megaspores usually lie in a row parallel to the long axis of the nucellus (FIG. 18). That the first division may be longitudinal is shown by preparations similar to that in FIG. 10, and that the later divisions may vary from a transverse direction is shown in the upper cell in FIG. 22. From such divisions we might expect the formation of two parallel rows of two megaspores each, or a row of two parallel to the long axis of the nucellus with another transverse pair, as described for *Symplo-*

carpus foetidus by Rosendahl (6, p. 3). Where more than one megaspore mother cell is in a nucellus, division of all the nuclei proceeds regularly and may or may not be simultaneous. The most nearly simultaneous cases found are shown in FIG. 9, 19, 19*a*. Finally, limited space probably causes a crowding in such cases, which results in the checking of activity in some cells and their destruction by the growth of others, as suggested by the cells at the left in FIG. 15, 15*a*.

A few preparations show a cell in a position to indicate its origin as a tapetal cell (FIG. 17*t*). The same possibility is suggested by Gow (5, p. 39–40), in FIG. 6, and is also mentioned by Campbell (3, p. 7) for *Dieffenbachia Seguine*. Such a tapetal structure is shown to be well developed normally in *Symplocarpus foetidus* by Rosendahl (6, p. 2, *pl. 1. f. 4* and *pl. 3. f. 31*). The finding of but one such cell showing disorganization as the megaspores develop seems to the writer sufficient evidence to justify the conclusion that the formation of a functional tapetum in *Arisaema triphyllum* is unusual or even questionable.

As has been stated above, during the enlargement and divisions of the megaspore mother cells, the outer cells of the nucellus undergo periclinal divisions until the sporogenous cells appear quite deeply seated. During the same time the nucellar cells become well filled with starch (FIG. 15 and 17). As a result of the later gametophyte growth, the lateral portion of the nucellus with its contained food material is consumed, so that the mature embryo-sac is in contact with the inner integument, except at the apex, where a cap of nucellar cells persists (FIG. 20 and 21). The temporary storage of food where it is so readily available for use by the growing embryo-sac may account for the rapid development of the latter as given below.

THE EMBRYO-SAC

One of the megaspores develops into the embryo-sac at the expense of the others and of the nucellar tissue. Three nuclear divisions occur in rapid succession as in *Symplocarpus foetidus* (6, p. 3). The short time required for these divisions is indicated by the fact that out of many preparations of material gathered at one time, and showing about this stage, but very few show

anything between the first nuclear division of the megaspore (FIG. 20) and the mature embryo-sac (FIG. 20). The daughter nuclei of the first division remain centrally located in the cell until after the second division (FIG. 26). Later a normal egg cell and two synergidae are formed close in the apex of the embryo-sac, and in some cases three antipodals are present (FIG. 20). The antipodal cells are poorly developed however, only occasionally showing typical angiosperm structure, and never showing the remarkable development described by Campbell (3, p. 11) and Rosendahl (6, p. 5) for other members of the Araceae. As far as the writer has been able to determine, the polar nuclei show no such fusion as described by Gow (5, p. 41), but remain separate as in *Anthurium* (3, p. 15). In every case where a polar nucleus was observed after fertilization of the egg, the lower one was found separate, greatly enlarged, and often disintegrating near the antipodals. Further details concerning the fate of the polar nuclei and of the antipodal structure will be more fully dealt with in a subsequent paper.

Where more than one tetrad of potential megaspores are formed in one nucellus, the usual course of events is for some one cell from one tetrad to germinate while the other spores are crushed or broken down. In rare cases more than one embryo-sac have been found developing in the same nucellus. In one ovule two well-developed embryo-sacs were found side by side and of approximately the same size, but unfortunately one lay directly beneath the other in the section. The only preparation showing two such structures in the same section is shown in FIG. 21. These present a marked difference in size as well as deficiencies in antipodal structure. As stated above, such imperfect development of antipodals is not rare in otherwise normal embryo-sacs.

SUMMARY

The present study has verified most of the findings of other investigators, but has given results at variance with their reports in regard to the following points.

(*a*) The origin of the several megaspore mother cells from a single primary archesporial cell is doubtful.

The first division in the formation of the tetrad has been probably mistaken by earlier investigators for a division of a primary archesporial cell into embryo-sac initials.

(*b*) The formation of a tetrad of potential megaspores from some of which the embryo-sac or sacs develop, instead of from an archesporial cell, is shown.

(*c*) More than one embryo-sac may be developed in *Arisaema triphyllum*, as Campbell (4, p. 671) has shown for other members of the Araceae.

(*d*) The fusion of the polar nuclei is doubtful.

(*e*) The antipodal cells rarely develop fully as in typical angiosperms.

The writer wishes to express his gratitude to Prof. D. M. Mottier of Indiana University, at whose suggestion the present study was undertaken, for his kindly critical and encouraging words.

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Description of plates 13 and 14

All drawings were made with the aid of a camera lucida.

FIG. 1. Longitudinal section of a young ovule with two megaspore mother cells in normal position shortly after the beginning of differentiation. ×225.

FIG. 2. Longitudinal section of young ovule with three sporogenous cells differentiated. The two lower cells may be considered as lateral hypodermal cells. ×225.

FIG. 3. Longitudinal section of ovule slightly larger and older than those shown in FIG. 1 and 2, but without any clearly differentiated sporogenous cells. ×225.

FIG. 4. Longitudinal section of very young ovule before differentiation of sporogenous cells and beginning of integuments. ×335.

FIG. 5. Longitudinal section of ovule showing lateral megaspore mother cell, a possible tapetal cell at the right, and the beginning of periclinal division of epidermal cells. ×225.

FIG. 6. Longitudinal section of ovule showing one megaspore mother cell and completed periclinal division of epidermal cells. ×225.

FIG. 7. Cross section of nucellus showing layer of 2 to 3 cells surrounding three megaspore mother cells. ×335.

FIG. 8. Longitudinal section of the whole ovule and part of ovary walls. ×225.

FIG. 9. Cross section of nucellus similar to FIG. 7, but showing different arrangement of megaspore mother cells. This shows very nearly simultaneous preparation for nuclear division. ×335.

FIG. 10. Cross section of nucellus showing the spindle of a longitudinal first division of a megaspore mother cell. ×335.

FIG. 11. Longitudinal section of nucellus with four megaspore mother cells. The position of the two at the left suggests a possible origin from a common archesporial cell. ×225.

FIG. 12. Longitudinal section of ovule to show the development of the integuments at the time of preparation for first tetrad division. ×125.

FIG. 13. Cross section of nucellus to show irregularity of periclinal division of outer cells. ×335.

FIG. 14. Longitudinal section of ovule to show the development of integuments at the time of the first tetrad division. ×125. (See FIG. 16.)

FIG. 15. Longitudinal section of nucellus showing some sporogenous cells crushed by the growth of others. ×250.

FIG. 15*a*. Sporogenous cells of FIG. 15. ×830.

FIG. 16. Higher magnification of the nucellus shown in FIG. 14. ×250.

FIG. 17. Longitudinal section of nucellus showing a possible tapetal cell, *t*. ×250.

FIG. 18. Longitudinal section of nucellus.showing a row of four potential megaspores. ×250.

FIG. 19. Longitudinal section of nucellus showing two megaspore mother cells, one below the other. ×250.

FIG. 19*a*. Sporogenous cells of FIG. 19. ×830. The nuclei are in synapsis.

FIG. 20. Longitudinal section of ovule with one mature embryo-sac. ×160.

FIG. 21. Longitudinal section of ovule with two embryo-sacs. ×160.

FIG. 22. Longitudinal section of nucellus showing the second tetrad division and the wall formed after the first division. This shows the sporogenous cells buried unusually deep. ×250.

FIG. 23. Same as FIG. 22, but without any cell wall after the first division. ×250.

FIG. 24. A later stage than in FIG. 22. ×250.

FIG. 25. Section of a megaspore showing the first nuclear division. ×830.

FIG. 26. Section showing four nuclear stage in the development of the embryo-sac. ×830.

Is salinity a factor in the distribution of Nereocystis Luetkeana?*

GEORGE B. RIGG

Under an appointment from the United States Bureau of Soils the writer has investigated the kelps of the Puget Sound region as a source of potash fertilizer. This work was done during the summers of 1911 and 1912. During 1912 attention was given in particular to a study of the effect of fresh water on the growth of the bladder kelp (*Nereocystis Luetkeana*) as seen in the bed in Freshwater Bay near the mouth of the Elwha River. The Elwha is a snow-fed stream originating on the southwestern slope of Mount Olympus. It flows north and discharges into the Strait of Juan de Fuca some six miles west of the city of Port Angeles, Washington. It is the largest stream flowing into the Strait of Juan de Fuca or Puget Sound from the Olympic Mountains. The monthly maximum and minimum discharge of this river is reported in the Report of the United States Geological Survey,† in cubic feet per second, for the period of October, 1897, to December, 1898. For the portion of the year 1897 covered by this report the maximum discharge occurred in November and was 7,075 second feet, while the minimum occurred in October and was 171 second feet. For 1898 the maximum (3,282 second feet) occurred in June and the minimum (330 second feet) occurred in October. The mean for the period reported is 1,444 second feet. These observations were taken at McDonald, Washington. This is above the outlet of Lake Sutherland and also the outlet of Little River, so that the actual discharge of the river was somewhat greater than the above figures show. Mr. G. W. Northrup, superintendent of the operation of the power plant of the Olympic Power Company on the Elwha, states that the minimum discharge of the river for the year 1912 has been between 400 and 500 second feet, and that the maximum reaches an enormous amount each year during flood water periods, that is, in May and November.

† Published by permission of the Secretary of Agriculture.

* Twentieth Annual Report of the United States Geological Survey, Part IV, p. 531.

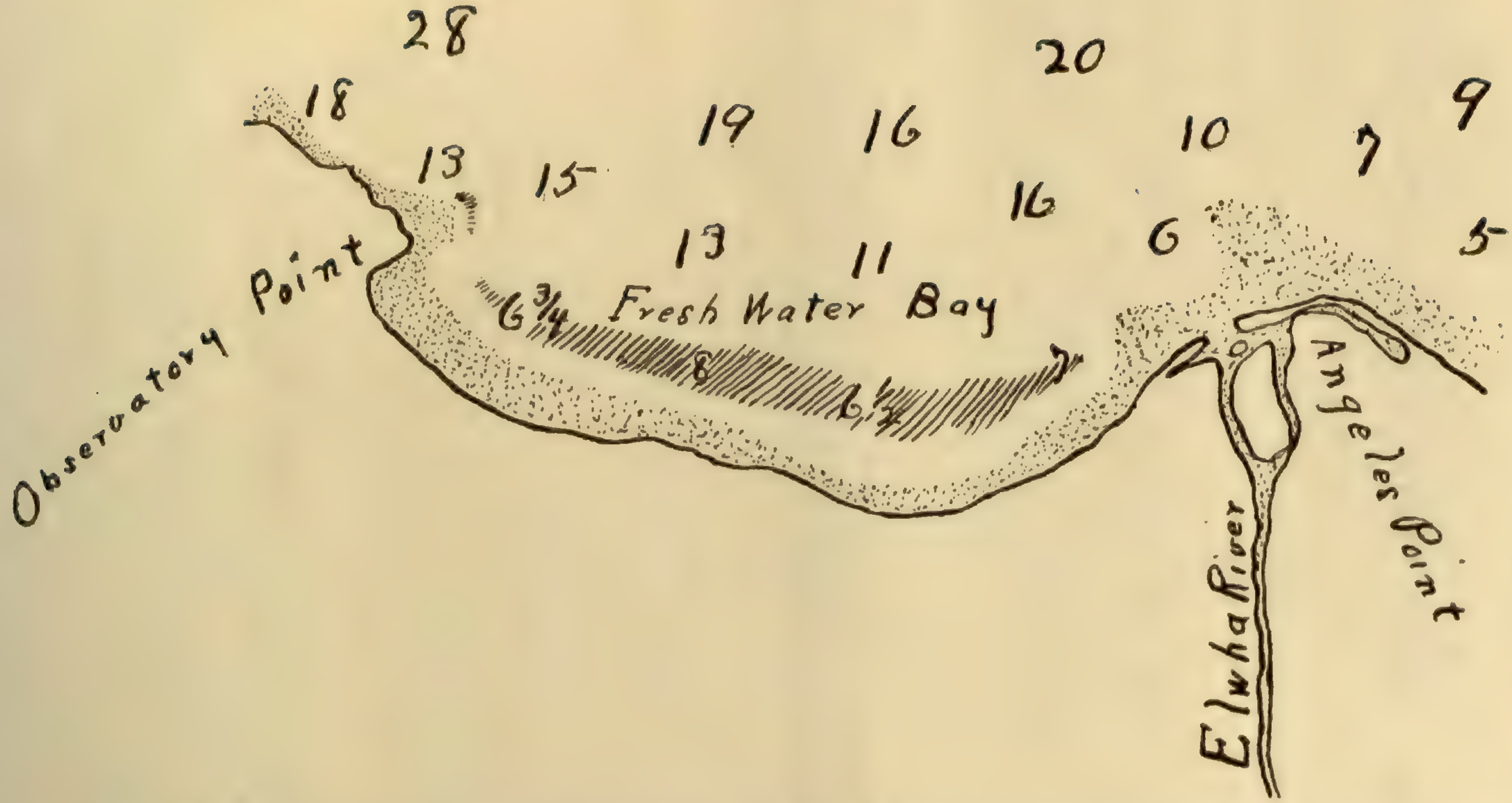

FIG. 1. Map of Freshwater Bay, Washington. Drawn from U. S. Coast and Geodetic Survey Chart no. 6300; kelp bed (*Nereocystis*) shown by ////////; soundings given in fathoms; dotted area indicates shoal water.

Freshwater Bay does not form a harbor. The distance in a straight line from Angeles Point, which marks the eastern side of the bay, to Observatory Point at its western side is four miles, while the maximum distance to shore in the bay, measured at a right angle from the above line, is only one mile. The strong tidal currents flowing in and out through the Strait of Juan de Fuca sweep freely through this bay. There is a good beach along practically the whole bay. The field observations on the kelp beds in this bay were made on September 11 and 12. On September 11, the surf was so heavy that it was deemed impracticable either to enter the mouth of the river in the 50-foot launch in which the trip was made, or to land with a skiff in the more exposed portion of the bay. The launch was anchored in the more protected portion of the bay behind Observatory Point. A landing was readily made with the skiff from this point. On the afternoon of September 12, the water in the bay was much quieter and we entered the mouth of the river in the launch.

There is no kelp at all opposite the mouth of the Elwha River. The river enters the bay by two mouths and the first kelp plants found were about half a mile west of the west mouth. At this end of the bed the kelp plants are scattering and of medium size. A little farther west the bed becomes quite dense, and continues so to a point near Observatory Point. The bed is not closer to the beach than one fourth of a mile at any point. The bed is more than 500 feet wide in places and is over two miles long. There is also a good deal of kelp around Observatory Point. The bladder kelp (*Nereocystis Luetkeana*) is the only kelp found growing in this bed. *Macrocystis pyrifera* was found floating in the bay, but not attached.

Hydrometer readings to determine the density of the water were made at the most eastern point at which kelp was found in the bay, at the west end of the bed, and at several intermediate points. Readings for comparison were made at several points in the open Strait also. A reading was made in the mouth of the river and one at a point about 500 feet directly out from the mouth. All readings were taken at a temperature of 15.5° C., that being the temperature to which the zero point of the instrument used was adjusted. The water of the river proved to be

exactly this temperature, while the samples from the kelp bed and the open Strait varied from 12.5° C. to 13.5° C. There was found to be no difference in the hydrometer readings taken in the open Strait and those taken at any of the points where kelp grew in the bay. The reading taken in the mouth of the river was zero. The reading taken about 500 feet straight out from the mouth of the river showed about one third as great a salinity as the water of the Strait and of the bay.

The facts are, then, that a strong tidal current sweeps freely through this kelp bed, and the water at all points in it shows the normal salinity of the water of the Strait. So far as this bed is concerned kelp does not grow in water that has less than the normal salinity. It does not seem quite possible, however, to say positively that the lack of normal salinity is the only inhibiting factor preventing the growth of kelp near the mouth of the river, although it seems to the writer that such is probably the case. Outside of the question of the salinity of the water, there are at least three factors that limit the distribution of *Nereocystis* in the Puget Sound region. These are rocks for anchorage, a strong tidal current, and proper depth of the water. The strong tidal current is present at the mouth of the river, as it is in the other portions of the bay, and the water is of proper depth for kelp, a little distance off shore, as it is in the other portions of the bay, where kelp does thrive abundantly. It may be possible that the silt brought down by the river has so covered the rocks near the mouth of the river as to render the attachment of kelp impossible.

Two sets of samples were collected—one set from the extreme western end of the bed (over three miles from the mouth of the river) and one set from the extreme eastern end (the portion of the bed nearest the mouth of the river). The analysis of these samples is shown in the following table.

The above figures should not be construed as indicating positively any characteristic difference in the potash content of the kelp from the two ends of the bed. It will be noted that sample number 3 has a much higher potash content than any other sample reported in the table. Neglecting this one, the samples from the west end of the bed average about one per cent higher in potash than the samples from the east end. This, however, should be

considered in the light of the fact that two samples of fronds collected by the writer in the Brown's Island bed near Friday Harbor, Washington, in 1911, and analyzed by Dr. J. W. Turrentine of the United States Bureau of Soils differed in their potash content by 9.7 per cent.*

COMPOSITION OF KELP SAMPLES (*Nereocystis Luetkeana*) FROM FRESHWATER BAY, PUGET SOUND. Collected by George B. Rigg. Analyses by E. G. Parker and J. R. Lindemuth, U. S. Bureau of Soils. Nitrogen determinations by J. C. Trescott, U. S. Bureau of Chemistry.

No.	Locality	Portion of plant	Potash, per cent.	Nitrogen, per cent.	Iodine, per cent.	Soluble salts, per cent.	Organic matter, per cent.	Ash, per cent.
1	From west end of bay	Fronds	18.04	2.26	0.23	44.17	51.13	4.80
2		Fronds	17.61	2.21	0.24	44.70	51.11	4.72
3		Stipes	31.62	1.21	0.25	63.75	33.15	3.46
4	From east end of bay	Fronds	16.92	2.57	0.20	43.37	51.16	5.47
5		Fronds	17.05	2.71	0.24	41.53	51.67	6.30
6		Fronds	17.32	2.53	0.28	45.40	50.12	4.48
7		Fronds	16.20	2.54	0.19	42.88	52.19	4.98
8		Stipes	16.50	2.21	0.30	59.24	37.40	3.36
9		Stipes	16.72	1.46	0.20	57.06	39.02	3.92

It is quite possible that in some states of tide and current the water may be less saline at the east end of the bed than at the west end, and that this may account for the slightly lower potash content in the samples from the east end.

There seems to have been little previous work done on the influence of the varying salinity of water on the growth of the Laminariaceae. Setchell† says that "Exact figures are wanting" and that "Recourse may be had only to general experience and statements can be couched only in general terms." He says that a few Laminariaceae "ascend tidal rivers to a slight extent." The writer has not found any instance of this in the Puget Sound region, but his investigation particularly of the smaller leaf-like species has not been by any means complete.

Setchell notes the fact that Fucaceae and Ulvaceae are found in tidal rivers. This is true in the Puget Sound region. It is interesting in this connection to note that a *Pelvetia* plant has even been found growing in a salt marsh in this region. The specimen

* Sixty second Congress, Second Session. Senate Document No. 190, p. 220.

† Ibid., p. 135.

referred to was found by Dr. T. C. Frye in a marsh near Toke Point, Washington.

While the writer has not made any detailed investigations in regard to the growth of Laminariaceae near the mouth of any other river than the Elwha, his general observations as well as his conversations and correspondence with other observers lead him to believe that kelps are to be looked for in this region only where the water has practically the normal salinity of sea water.

UNIVERSITY OF WASHINGTON, SEATTLE.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1910–1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Forty-two new species are described.

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Includes descriptions of *Fusarium redolens*, *F. conglutinans*, and *F. Sclerotium*, spp. nov.

PHLEBODIUM AUREUM L.

CYRTOMIUM BOYDIAE (D. C. EATON) W. J. ROBINSON

SADLERIA HILLEBRANDII W. J. ROBINSON

SADLERIA UNISORA (BAKER) W. J. ROBINSON

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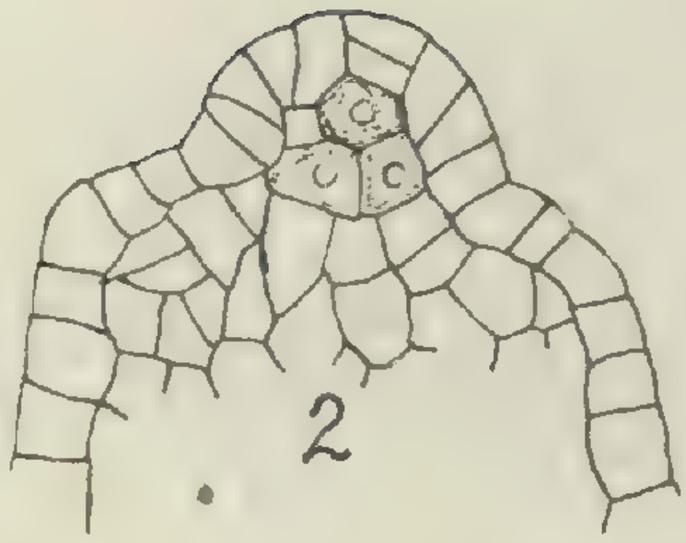
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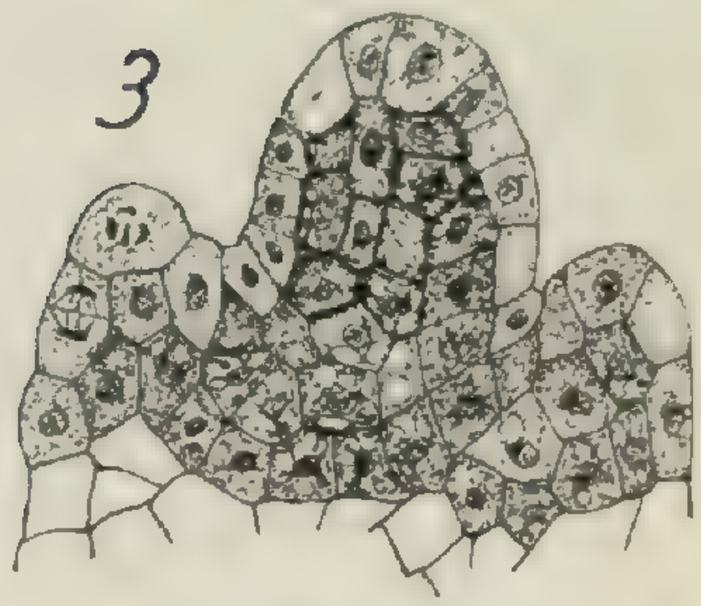
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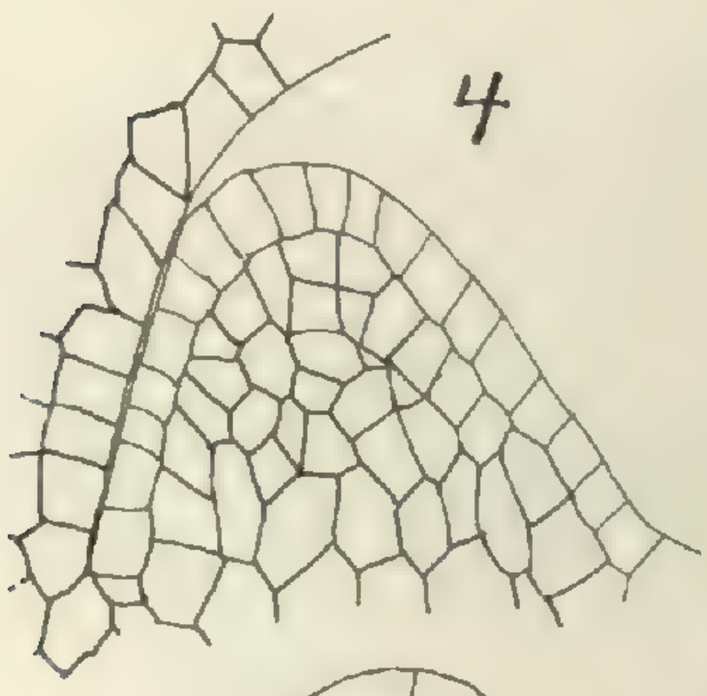
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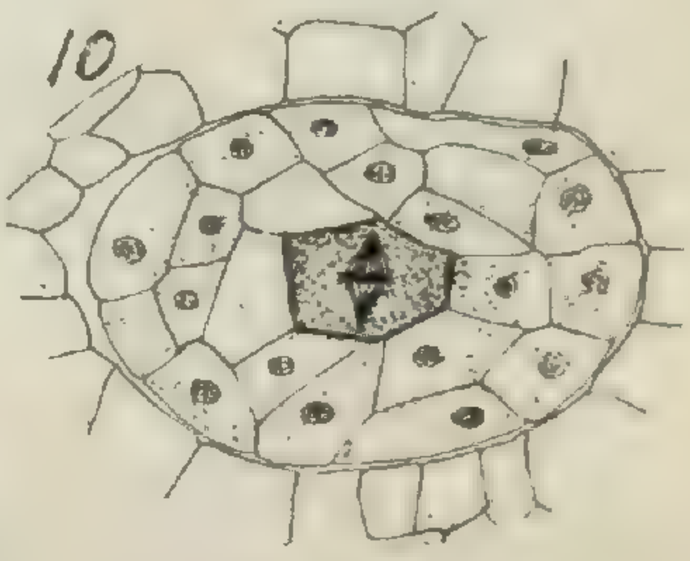
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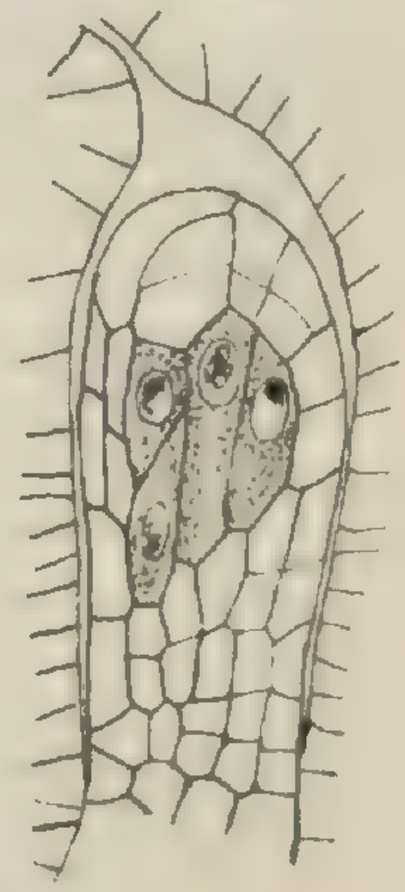
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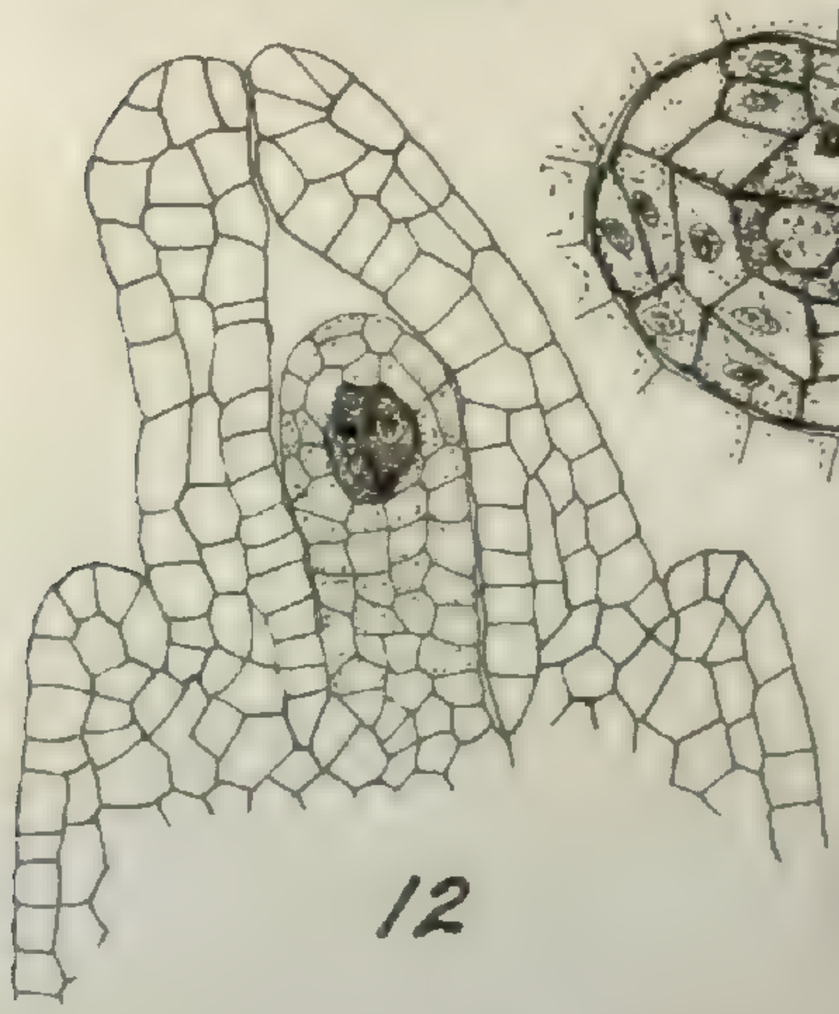
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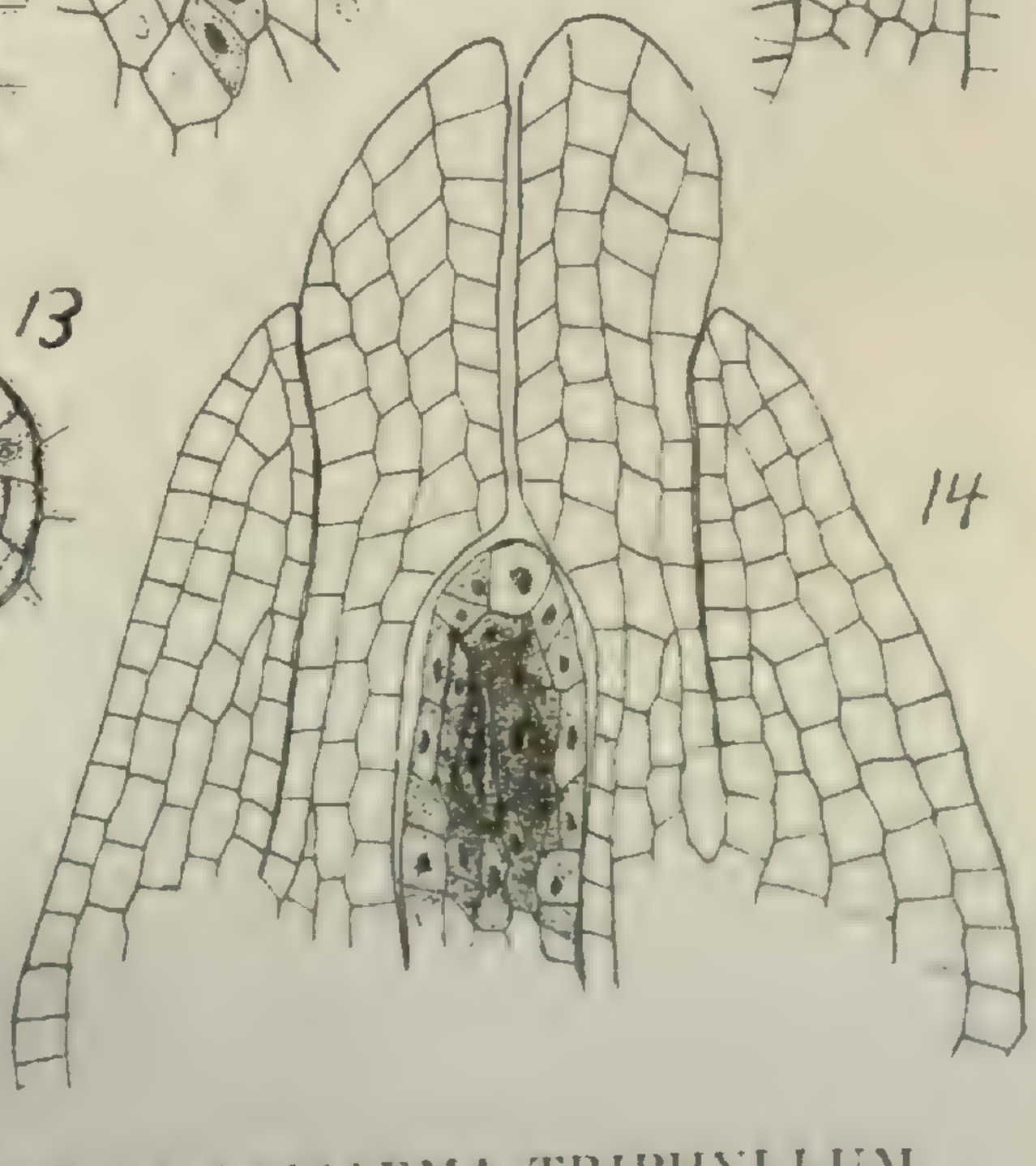
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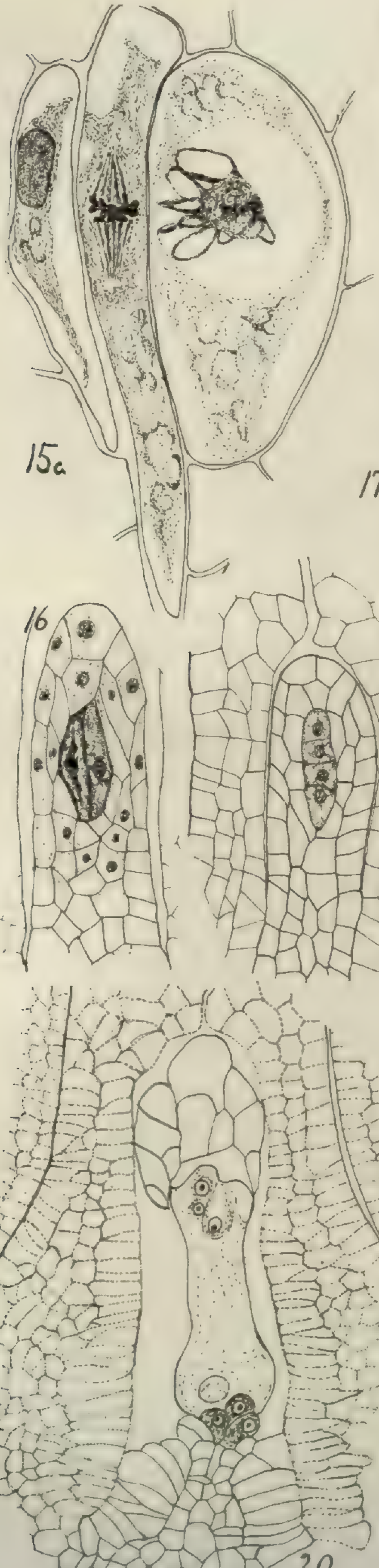
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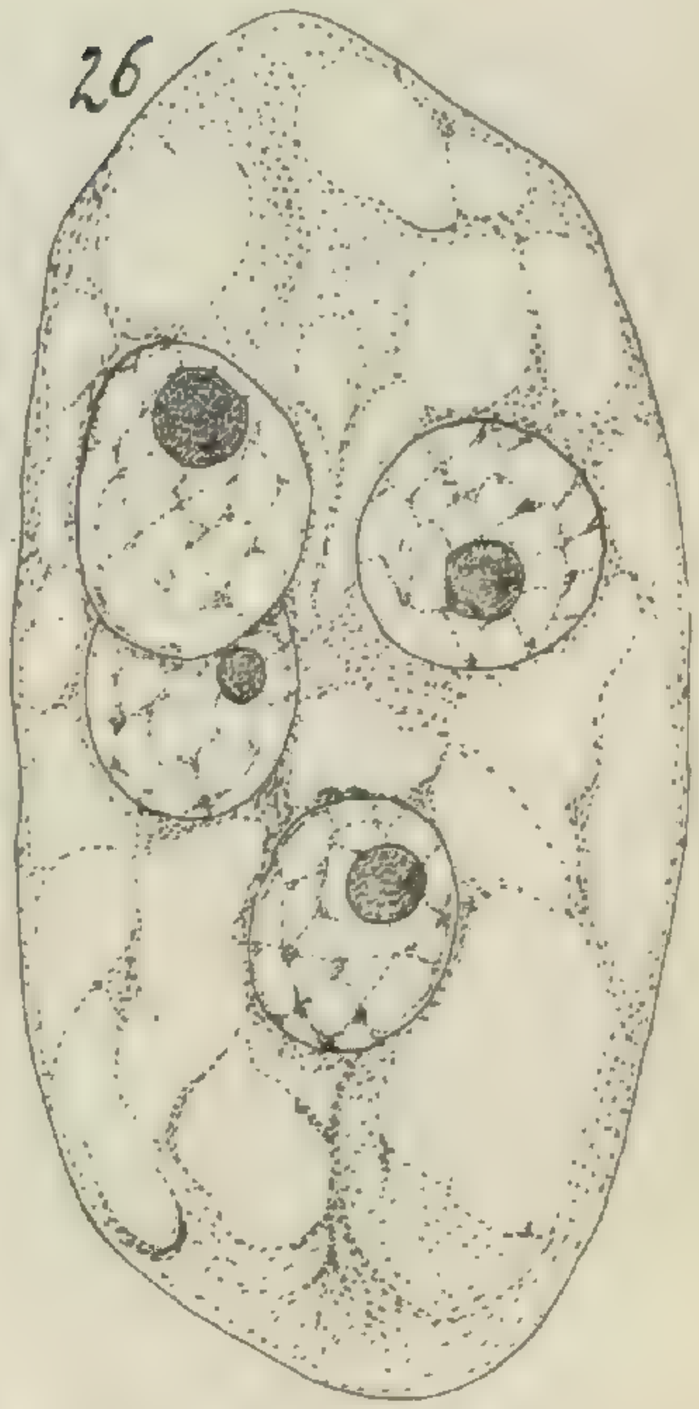
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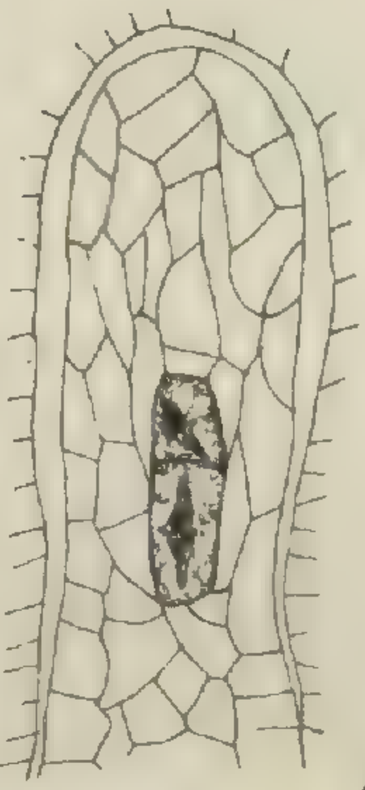
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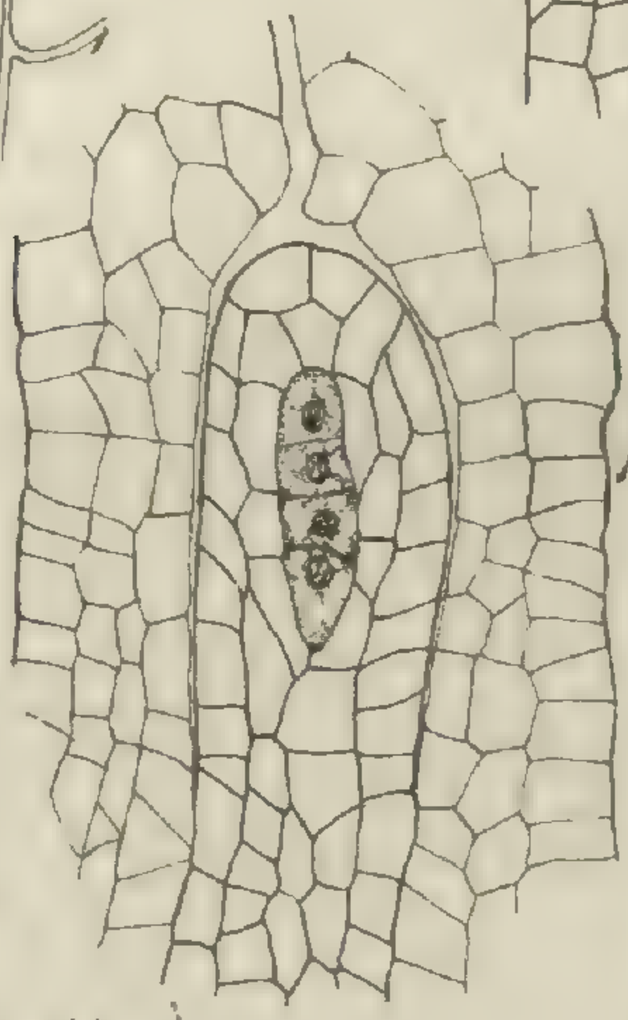
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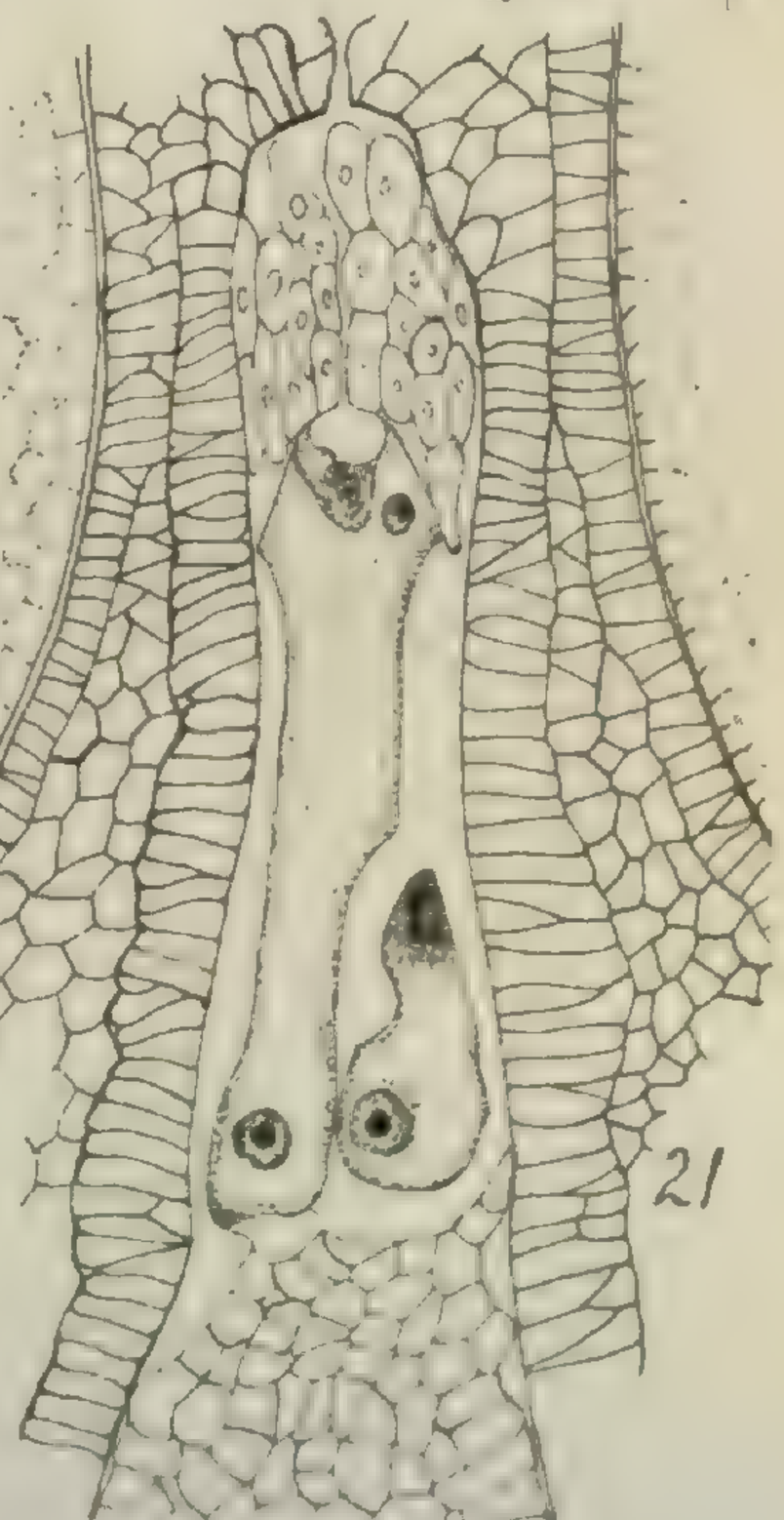
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PICKETT: EMBRYO-SAC OF ARISAEMA TRIPHYLLUM

Vol. 40 No. 6

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE, 1913

Four hybrids of Viola pedatifida

EZRA BRAINERD

(WITH PLATES 15–17)

The hybrids between *Viola pedatifida* and allied species are in several respects the most interesting among the 75 or 80 that have appeared in the genus as represented in North America. At least two of the four are remarkably hardy, almost immune from attacks of fungus, and comparatively fertile; they are therefore well suited for experimental cultures. The marked contrast in leaf outline displayed in the parents of the several crosses affords a fine opportunity for studying in detail the many diverse forms of leaf that emerge in the offspring of the hybrid. The other opposed parental characters, relating to pubescence, color of capsule, color of seed, length of peduncle, and villosity of spur petal, also lead to results well worthy of careful study.

One of these hybrid plants I have had in hand for eight seasons and have raised from it over 450 offspring, extending through four generations. It was discovered at Yorkville, Ill., May 1905, by Miss Mary O. Pollard, a former pupil, and may be briefly described as follows:

1. **Viola papilionacea** × **pedatifida** hyb. nov.

Rootstock stout, at length extensively branching horizontally; leaves broadly deltoid-ovate in outline, cleft into 7–11 linear or oblong lobes, the middle lobe much the widest, glabrous, though the margins are often scabro-ciliolate; petals violet, the odd one more or less villous; cleistogamous flowers on erect or ascending peduncles, intermediate in length to those of the parent species; capsules 8–12 mm. long, infertile, averaging in 12 capsules $8\frac{1}{4}$

seeds; seeds brown, 2 mm. long; offspring notably diversiform. (PLATE 15, *Aa*.)

Several sowings have been made of the seeds of this hybrid; but the ten plants of the first brood (236), whose offspring have been raised for two succeeding generations, are the only ones that will be here discussed. The forms of leaf found in the ten plants and in their respective broods of offspring are presented in the first half of TABLE I. The second half presents the corresponding facts regarding sixteen offspring of brood 236, plant 3, whose leaf had a hybrid form, quite the same as that of the mother plant from Illinois.

TABLE I

CULTURES OF VIOLA PAPILIONACEA × PEDATIFIDA FOR FOUR GENERATIONS

V. papilionacea has leaf uncut:—*a*
V. pedatifida has leaf parted:—*A*
Their HYBRID has leaf cleft:—*Aa*

Ten F_2 offspring of hybrid

Brood 236	Leaf form	Their offspring—F_3 Brood	Number and form *A*	*Aa*	*a*	Total
No. 2	*A*	595	30			30
No. 3	*Aa*	468	6	5	5	52
		596	8	20	8	
No. 4	*Aa*	597	3	6	1	10
No. 6	*a*	598			16	16
No. 7	*A*	599	16			16
No. 8	*Aa*	600	1	10	3	14
No. 9	*Aa*	601	2	1	1	4
No. 10	*Aa*	602	6	6	3	15
No. 11	*A*	603	13			13
No. 12	*Aa*	604	3	5	2	10
	Total.....		88	53	39	180
	From *Aa*'s ...		29	53	23	105

Sixteen F_3 offspring of 236–3

Brood 468	Leaf form	Their offspring—F_4 Brood	Number and form *A*	*Aa*	*a*	Total
No. 1	*A*	605	12			12
No. 2	*Aa*	606	3	5	5	13
No. 3	*Aa*	607	4	6	3	13
No. 4	*A*	608	14			14
No. 5	*a*	609			15	15
No. 6	*A*	610	20			20
No. 7	*a*	611			11	11
No. 8	*A*	612	14			14
No. 9	*a*	613			16	16
No. 11	*Aa*	615	3	6	3	12
No. 12	*Aa*	616	3	7	3	13
No. 13	*A*	617	12			12
No. 14	*A*	618	12			12
No. 15	*a*	619			12	12
No. 16	*Aa*	620	2	7	4	13
No. 17	*a*	621			14	14
	Total		99	31	86	216
	From *Aa*'s...		15	31	18	64

The cultures show that in this hybrid the Mendelian law controls in a general way the inheritance of leaf form, though there is no dominance, the hybrid leaf being intermediate between the leaves of the two parents. The plants that resemble *V. pedatifida* in having parted leaves always produce offspring with parted leaves; those that resemble *V. papilionacea* in having uncut leaves always produce offspring with uncut leaves; while those

that have the compromise leaf reproduce plants with three forms of leaf incision, as did the original hybrid. Also in the relative *number* of these forms there is an approximation to the Mendelian ratio 1 : 2 : 1. In the above 26 plants (broods 236 and 468), whose forms were verified by their offspring, there are 9 *A*'s, 11 *Aa*'s, 6 *a*'s, the theoretical ratio being: $6\frac{1}{2}$ *A*'s, 13 *Aa*'s, $6\frac{1}{2}$ *a*'s. In the 169 offspring of *Aa* plants, given above for the third and fourth generations, there are 44 *A*'s, 84 *Aa*'s, 41 *a*'s, the theoretical ratio being: $42\frac{1}{4}$ *A*'s, $84\frac{1}{2}$ *Aa*'s, $42\frac{1}{4}$ *a*'s. Here we find, as usual, that the larger the number of individuals the closer the normal ratio is realized.

But besides general conformity there are also departures from the strict Mendelian law. For one thing the hybrid or intermediate leaf varies in different individuals, inclining now more to the form of the one parent species and now more to the form of the other. Also the reversionary forms, designated as *A* and *a*, are rarely complete reversions. The *A* plants, though stable in producing like parted leaves in succeeding generations, do not have leaves as *deeply* parted as in *V. pedatifida;* and the *a* plants, though plainly uncut and stable, usually have teeth noticeably longer than in normal *V. papilionacea*, sometimes even pectinate. (PLATE 15, FIG. *a*.)

Another cause often conspires to increase these differences in leaf pattern: the presence of minor hybrid characters that independently adjust their special conflicts of hybridity. For example, the leaf of *V. pedatifida* is usually truncate or even cuneate at the base, that of *V. papilionacea* usually cordate. A hybrid offspring may inherit the broad truncate base of the former with the uncut margin of the latter. Sometimes in the hybrid leaf the lobes are entire, and obtuse at the tip; sometimes, as in the normal leaf of *V. pedatifida*, the lobes are again cleft or toothed on the outer margin, and acute at the tip.

In these various ways there has arisen in the numerous progeny of the hybrid under discussion a considerable diversity of foliage, such as would present insoluble difficulties to a taxonomic student, who did not know that these diverse forms all came from one individual, by close-fertilized reproduction, in the short period of three or four years. The extreme differences are such as would

warrant the making of several distinct species, according to the hasty methods of ordinary practice.

The hybrid *V. papilionacea* × *pedatifida* seems not to be rare in the Middle West. I cite a few interesting examples: *M. A. Castleton 25*, Vinita, Okla., April 18, 1891; distributed as "*V. palmata*."* From the United States National Herbarium in 1911 was distributed with printed ticket: "*Viola Bernardi* Greene, Freeport, Ill., *Charles F. Johnson*, May 15, 1899; determined by Dr. E. L. Greene and Philip Dowell." The plant is quite the same as the hybrid under discussion from Yorkville, Ill., and seems to represent Dr. Greene's present conception of his species. *V. indivisa* Greene is also a derivative form of this hybrid; the "type" from Prairie Junction, Minn., *E. L. Greene* coll., July 7, 1898 (Pittonia 5: 124. *pl. 13*. 1903). Also along railway, Naperville, Ill., *L. M. Umbach*, May 18, 1897. (Cf. Leaflets 1: 182. 1906.)

2. **Viola pedatifida** × **sagittata** hyb. nov.

Plant becoming cespitose, the rootstock dividing into several erect branches; leaves that develop after petaliferous flowering finely pubescent especially beneath and on the upper portion of the petiole, the blades subcordate-ovate in outline (the width about $\frac{2}{3}$ the length), cleft into 6–8 oblong-linear lateral lobes and a broad slightly toothed terminal lobe, the leaves of late summer relatively broader; petals violet, the three lower villous; apetalous flowers and fruit on erect peduncles as long as the petioles; auricles of sepals long and divergent; capsules green, 6–10 mm. long, often quite infertile; seeds intermediate to those of the two parent species in size and color; offspring much unlike each other in foliage, but blades always incised or coarsely toothed toward the base. (PLATE 16, FIG. *Aa*.)

This hybrid first attracted my attention in a parcel of violet specimens collected in central Illinois by Mr. V. H. Chase, and sent me in November 1907 for determination. It was found in undisturbed prairie soil along the right of way of the Rock Island and Peoria Railroad, just north of the south boundary of Stark County. At the same place and time were collected *V. pedatifida* and pubescent *V. sagittata*, the three plants bearing the consecutive numbers *1356–7–8*. The anomalous plant impressed me as

* Regarded as *V. viarum* by Mr. Pollard, and apparently the basis for accrediting this species to Ind. Terr. in Britton's Manual, p. 636. 1905.

distinct from *V. pedatifida* × *sororia*, discussed below, and as a cross between the two species with which it grew. Mr. Chase, to whom I appealed for living plants, found that the station had been recently burned over; but the following May he discovered another colony along the railway a half mile farther south (*V. H. Chase 1619*). The stocky specimen sent was easily divided, and six or eight vigorous plants were obtained during the season of 1908. Mr. Chase reported that the pubescent *V. sagittata* "was very abundant, thousands of plants cover the ground with a blue carpet, mostly where the land was a little low and damp. *V. pedatifida* seemed to prefer rather drier ground. The hybrid was invariably with *V. pedatifida*, on fairly dry soil; and *V. sagittata* was never more than a few rods away."

During the season of 1909 I grew nineteen offspring of *Chase 1619*, and they gave abundant evidence as to the taxonomic status of the mother plant. Leaves of nine of these offspring are figured in PLATE 16 and indicate something of the marked diversity of form resulting from the combination, in the leaf of the original hybrid, of at least four pairs of opposed characters,* that blend or segregate, independently and variously, in the several offspring.

3. **Viola pedatifida** × **sororia** hyb. nov.

Becoming cespitose with multicipital caudex; leaves that expand at petaliferous flowering 9–13-cleft, the lateral lobes broadly linear, usually with one or two coarse teeth on the outer edge toward the apex, the middle lobe much broader and incised on either side, the upper face somewhat hirtellous, the lower surface and the petioles villous; the leaves of summer larger and less deeply cleft; apetalous flowers on rather short, erect or ascending peduncles; the capsules somewhat blotched with purple, bearing 5–20 brown seeds 2 mm. long; offspring markedly dissimilar. Not rare on prairies of the Middle West. (PLATE 17.)

I am greatly indebted to the kindness and skill of Mr. Chase for the abundant and excellent material used in the study of this hybrid. Collectors in this region know that the native flora of the open prairies is now largely restricted to untilled strips of land

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*These are:	*V. pedatifida*	*V. sagittata*
1. Outline	broadly flabelliform	lanceolate
2. Form of base	truncate or cuneate	cordate or subcordate
3. Incision	2–3-ternately dissected	coarsely toothed at base
4. Pubescence	margins and veins hirtellous	finely pubescent

along the borders of railways. On May 16, 1909, Mr. Chase, whose bicycle was adjusted to run on rails, traversed in 5 hours the 24 miles between his home at Wady Petra and the town of Galva. In order to make the return by train, he says, "I could not stop to *hunt* along the way; but whenever I saw a cut-leaved violet that was not *V. pedatifida* I stopped for it." The twelve numbers of living plants collected on this trip reached me safely, and all have flourished in the Vermont garden.

The status of hybrid plants in the wild is well shown by a detailed study of these specimens and of their offspring; for all but two sterile plants have been reproduced by seed. The main points regarding them, that have a bearing on the present problem of hybridism, are presented in the following tabular synopsis (TABLE II):

TABLE II

VIOLET PLANTS COLLECTED BY V. H. CHASE IN CENTRAL ILLINOIS, MAY 16, 1909

	Chase's herb. no.	Leaf characters		Capsule color	Seed color	Av. no. in one capsule
V. pedatifida Don	1951, 1956	**A** (parted)	**b** (glabrous)	**c** (green)	**d** (buff)	70
V. sororia Willd...	1291	**a** (uncut)	**B** (villous)	**C** (purple)	**D** (brown)	66
V. papilionacea Ph.	1958	**a**	**b**	**C**	**D**	66
V. papilionacea × *pedatifida*	1950	*Aa*	*b*	sterile		0
	1952	*a*	*b*	*c*	*Dd*	7
	1949	*Aa*	*b*	*Cc*	*d*	$9\frac{2}{3}$
	1947	*Aa*	*b*	*Cc*	*Dd*, or *d*	5
V. pedatifida × *sororia*	1957	*Aa*	*Bb*	sterile		0
	1955	*A*	*Bb*	*Cc*	*Dd*	$10\frac{1}{2}$
	1953	*Aa*	*Bb*	*c*	*Dd*	7
	1954	*Aa*	*Bb*	*Cc*	*Dd*	8
	1948	*Aa*	*Bb*	*Cc*	*Dd*	18

Nos. 1951 and 1956 are *V. pedatifida;* and I have added to the list, though not collected May 16, 1909, *V. sororia*, the other parent of the hybrid under discussion; specimens of this had been previously sent me by Mr. Chase from four stations in his vicinity. No. 1958 is the prairie form of *V. papilionacea*, named *V. pratincola* by Dr. Greene (Pittonia 4: 64. Jl 1899). These three are common and widespread species of the Prairie States from Canada to Texas; the first and third reach westward to the mountains of Colorado.

Four of the numbers are the hybrid *V. papilionacea* × *peda-*

tifida, already discussed in this paper. Of these no. 1950 flowers freely in May with showy flowers, that often appear also in July and August; but apetalous flowers are rare, and neither sort has been found to produce seed. The three others are also nearly sterile, bearing only 5–10 seeds to a capsule; but none of the three turns out to be like the Pollard plant from Yorkville in being a first cross (or F_1), the form to be selected as the starting point for experiments on the laws of inheritance in hybrid offspring. No. 1952 has an uncut leaf as in *V. papilionacea* and a green colored capsule as in *V. pedatifida*, both recessive or reversionary characters never found in a first cross. No. 1949, on the other hand, has the hybrid leaf and the hybrid capsule color but the buff seeds of *V. pedatifida* and is therefore another subhybrid. No. 1947 consists of five plants, the seeds of which differ in color, and the leaves of which, though somewhat incised, display at least three unlike patterns; the five plants therefore must be considered the offspring of an earlier hybrid.

The remaining plants of the 1909 collection are equally variant forms but of *V. pedatifida* × *sororia*. No. 1957 is of dwarf habit and has the compromise or hybrid leaf; but though vigorous and multiplied by division into eleven plants, it has failed to yield a single seed. No. 1955 (six plants by division) has a leaf more deeply cut that the others, and this style of leaf reappears in all its offspring. In this we see a reversion, far from complete but stable, to the leaf of *V. pedatifida*. No. 1953 (again six plants by division) has the pure green capsules of *V. pedatifida*, as have also its offspring, and so is another subhybrid. But the two remaining numbers, 1954 and 1948, seem to be the desired first product of hybridism, all the four pairs of opposed characters in the double parentage appearing in a compromise form in both numbers. A flowering specimen of 1954 was distributed in my "violets of eastern North America, 1910," no. 121; and in no. 122 are shown two sister offspring, one with the uncut leaves of *V. sororia*, the other with the parted leaves of *V. pedatifida*.* No.

* In one of our large herbaria, where the work of mounting is done by novices, these two offspring were considered too unlike to appear on the same sheet. Only the plant with uncut leaves was mounted over ticket 122; while the sister plant with parted leaves was placed on the sheet with no. 121, which indeed it more closely resembled. That two plants so dissimilar should come from one self-fertilized parent has seemed incredible even to certain "botanists."

1948, being unusually fertile for a hybrid, was chosen for the basis of a somewhat detailed study of the reproductive behavior of a tetrahybrid.

During the season of 1910 twenty-one plants were grown from the seeds of *Chase 1948*. In August nearly all bore cleistogamous flowers, which matured several capsules of seeds. These were sown about December 1 in shallow boxes and placed in a cold frame with no protection from the winter weather but a covering of burlap. In the spring of 1911 all but seven of these sowings gave broods of F_3 offspring, containing each 6–18 plants. These have been carefully observed for two seasons and the characters of each plant noted as respects leaf incision, pubescence, color of capsule, and color of seed, four qualities in which the parent species were opposed. In each of these four qualities the plant resembled either *V. pedatifida*, *V. sororia*, or their hybrid; and in most instances the data were at hand, and clear enough, to determine at once this resemblance by inspection. In the case of the sixteen F_2 plants of brood 781, here made use of, the characters were verified by the behavior of their offspring, the reversionary forms always proving stable, the hybrid forms always unstable. The details of this experiment are given in TABLE III, in which the symbols *Aa*, *Bb*, *Cc*, *Dd* denote the blend or hybrid character.

The statements made above regarding the marked diversity of leaf pattern in the offspring of *V. papilionacea* × *pedatifida* and the departures from strict Mendelian law are equally true of the analogous hybrid *V. pedatifida* × *sororia*. The imperfect reversions in leaf form are shown in PLATE 17, FIG. *A.B*, *A.Bb*, and *A.b*, compared with the leaf of *V. pedatifida* figured above them. But in this hybrid the same phenomena are observable also in the varying colors of capsule and of seed. In all three pairs of characters the stable reversions marked *A*, *C*, and *D* are not complete reversions. The darkest capsule or seed found in the F_2 brood is much lighter than the capsule or seed of *V. sororia*.

It is further to be observed that though the Mendelian law leads us to expect on the average one of each of these reversions in every four offspring, we have here only one of each in the *sixteen* offspring. At the same time the *hybrid* forms are in excess of the

normal average (one half of the whole number); instead of 8 of each we have 10 *Aa*'s, 12 *Cc*'s, and 10 *Dd*'s. And it should be remembered that this statement is not based solely on the appearance of the F_2 plant but on the fact that the reversionary characters, *A*, *C*, *D*, were found to be stable in reproduction; while the hybrid characters were found to be unstable. For example, with the exception of no. 4, which had only two offspring, each of the ten *Aa* plants in brood 781 gave 2–7 plants with uncut leaves.

TABLE III

VIOLA PEDATIFIDA × SORORIA, CHASE 1948, AND ITS OFFSPRING

Hybrid F_1	*Aa*	*Bb*	*Cc*	*Dd*
Forms of sixteen F_2 offspring				

Brood	Foliage		Capsule	Seed
781 no. 1	*a*	*B*	*Cc*	*d*
781 no. 3	*a*	*B*	*Cc*	*d*
781 no. 4	*Aa*	*Bb*	*Cc*	*Dd*
781 no. 6	*A*	*Bb*	*Cc*	*Dd*
781 no. 7	*Aa*	*b*	*Cc*	*Dd*
781 no. 8	*Aa*	*B*	*C*	*d*
781 no. 9	*Aa*	*B*	*Cc*	*D*
781 no. 10	*Aa*	*b*	*Cc*	*Dd*
781 no. 11	*Aa*	*Bb*	*c*	*Dd*
781 no. 13	*a*	*Bb*	*Cc*	*Dd*
781 no. 14	*a*	*B*	*c*	*Dd*
781 no. 15	*Aa*	*Bb*	*C*	*d*
781 no. 16	*Aa*	*Bb*	*Cc*	*Dd*
781 no. 17	*Aa*	*Bb*	*Cc*	*d*
781 no. 19	*a*	*b*	*Cc*	*Dd*
781 no. 20	*Aa*	*b*	*Cc*	*Dd*

F_2 offspring of brood 781

Brood	Size	Exhybrids
853	13 plants	8 { 5 *a.B.C.d*; 3 *a.B.c.d*
855	10 plants	7 { 2 *a.B.C.d*; 5 *a.B.c.d*
856	2 plants	0
858	16 plants	3 { 1 *A.B.c.d*; 1 *A.b.C.d*; 1 *A.b.c.d*
859	7 plants	0
860	6 plants	4 { 2 *a.B.C.d*; 2 *A.B.C.d*
861	16 plants	3 { 1 *A.B.C.D*; 1 *A.B.c.D*; 1 *a.B.c.D*
862	14 plants	1 *a.b.c.D*
863	11 plants	2 { 1 *A.b.c.d*; 1 *a.b.c.d*
865	2 plants	0
866	9 plants	6 { 3 *a.B.c.D*; 3 *a.B.c.d*
867	15 plants	1 *a.B.C.d*
868	10 plants	0
869	18 plants	2 { 1 *a.B.C.d*; 1 *a.B.c.d*
871	8 plants	1 *a.b.c.d*
872	14 plants	3 { 1 *A.b.C.d*; 1 *A.b.c.d*; 1 *a.b.c.d*
	171 plants	41

And not only in the second but also in the third generation of this hybrid the number of plants having the positive character seems to fall short of the Mendelian requirements. This appears if

we note the ratio in which the several hybrid characters in brood 781 segregate in the F_3 offspring:

The 10 *Aa* plants had 113 offspring: 23 *A*'s, 54 *Aa*'s, 36 *a*'s	ratio in %	20:48:32
The 7 *Bb* plants had 74 offspring: 14 *B*'s, 35 *Bb*'s, 25 *b*'s		19:47:34
The 12 *Cc* plants had 130 offspring: 23 *C*'s, 67 *Cc*'s, 40 *c*'s		18:51:31
The 10 *Dd* plants had 93 offspring: 13 *D*'s, 44 *Dd*'s, 36 *d*'s		14:47:39
Total 410	73	normal ratio: 25:50:25

Combining these results, we find in 410 instances of the reproduction of a hybrid character, that instead of $102\frac{1}{2}$ reversions to the positive character there are only 73; instead of 25 per cent, only 18.

However, the determination of the characters in these 171 F_3 offspring rests only upon their appearance, having not been as yet verified by observing the behavior of the F_4 offspring. Of this generation 45–50 broods are hoped for by another season from seed already sown. But we seem to be already justified in the suspicion that in a species-hybrid as complex as the one under experiment, where the opposed characters of the parents appear in a blend or intermediate form, this form may acquire a certain degree of fixity, whereby the reversions to the positive type in a pair of opposed characters are less complete and less frequent than in normal Mendelian segregation and the reversions to the negative type more frequent. If we might assume that the gametes holding the positive character were more or less impure, while the gametes holding the negative character were pure, the situation would be fairly well accounted for.

In the great diversity of forms displayed in the 171 F_3 offspring the most interesting group are the 41 exhybrids, in which all of the four characters under study are reversionary and constant. Among these we find three plants in which the four characters of *V. pedatifida*, *A.b.c.d*, reappear, one plant in each of the broods 858, 863, and 872. What may be called a form of *V. pedatifida* with uncut leaves, *a.b.c.d*, is found once in each of the broods 863, 871, 872. A pubescent *V. pedatifida*, *A.B.c.d*, occurs in brood 858. A purple-capsuled *V. pedatifida*, *A.b.C.d*, occurs in both 858 and 872. Similarly, we have a cut-leaved *V. sororia*, *A.B.C.D*, in brood 861; a green-capsuled *V. sororia*, *a.B.c.D*, once in brood 861 and three times in brood 866; and a buff-seeded *V. sororia*, *a.B.C.d*, in broods 853, 855, 860, 867, and 869, eleven plants in all. In short, all but five of the sixteen possible combi-

nations in fours, of these eight pure elementary characters, are to be found in these 41 plants.

As showing how a hybrid tends in successive generations to eliminate its hybrid characters, ever becoming simpler and finally pure, we note that starting with the F_1 plants, necessarily hybrid in all the opposed characters of the two parent species, we have in the next generation only two such hybrids, and in the 171 plants of the 3d generation, none; indeed, the law of probability calls here for only one in every 256 offspring.

My first recognition of *V. pedatifida* × *sororia* was in a package of living plants sent May 22, 1907, by Dr. H. V. Ogden of Milwaukee, collected at Upper Nemahbin Lake, Wis., growing with both parents, and considered by him as "doubtless a hybrid." The same thing, however, had been sent me some three years earlier by Dr. Greene as a specimen of his *V. Bernardi*, collected by himself at Dixon, Ill., June 18, 1898. In Leaflets 1: 184. Ja 1906, the plant is transferred to *V. perpensa*, then first described. I have recently examined the three other specimens there cited and regard them all as forms of *V. pedatifida* × *sororia*.* Also *V. fallacissima* Greene, Leaflets 1: 185. Ja 1906, is another form of the same hybrid from western Missouri—*Bush 141*, Lee's Summit, Mo., July 8, 1899. Other specimens are: *E. J. Palmer 3345 and 3393*, Webb City, Mo., April 19 and May 5, 1911; *Mary O. Pollard 6*, Yorkville, Ill., May 16, 1909; *L. M. Umbach*, prairies, Clarendon Hills, Ill., June 21, 1899—distributed in 1911 from United States National Herbarium as "*V. palmata*."

4. **Viola nephrophylla** × **pedatifida** hyb. nov.

V. Wilmattae Pollard, Proc. Biol. Soc. Wash. **15**: 178. Au 1902†

Foliage much as in *V. papilionacea* × *pedatifida*, nearly glabrous, palmatifid with several narrow lateral lobes; corolla "deep violet, 2 cm. broad"; petals markedly villous and sepals with slightly scarious margins, as in *V. nephrophylla*.

It has not been practicable to secure living plants for cultures. But the alleged parent species were both growing in the cañon,

* I therefore wish to correct my statement in Bull. Torrey Club **37**: 584. 1910 that *V. perpensa* Greene is the western form of *V. palmata*—a too hasty inference from the fact that a *V. palmata* specimen in my herbarium from Aurora, Ill., was once named *V. Bernardi* by Mr. C. L. Pollard.

† The type is 404,924 United States National Herbarium, *Mrs. Wilmatte P. Cockerell*, Sapello Cañon (c. 8000 ft. alt.), Beulah, New Mex., May 5, 1901.

and the status of the plant is strikingly analogous to that of numbers 1 and 3 above described. The supposed hybrid has been recently again collected, by Mr. Paul C. Standley.* The leaves in his specimens are cut about halfway to the midrib; but on the same sheet are two detached leaves parted as in *V. pedatifida*, indicating that this species grew with the anomalous plant.

MIDDLEBURY, VERMONT

Explanation of plates

PLATE 1

Figures ½ natural size

Aa. *Viola papilionacea*×*pedatifida* Brainerd, transplanted, May 1905, from Yorkville, Ill., *Mary O. Pollard* coll.; ex horto Middlebury, Vt., May 14, 1910. No. 109 Brainerd's violets of eastern No. Am., 1910.

A. F_4 offspring of Aa, having stable leaf pattern resembling that of *V. pedatifida*; ex horto (brood 612) Middlebury, Vt., June 2, 1912.

a. F_2 offspring of Aa, having stable leaf pattern resembling that of *V. papilionacea;* ex horto (brood 236 plant 6) Middlebury, Vt., June 3, 1909.

PLATE 2

Figures ½ natural size

A. Leaf of *Viola pedatifida* Don, south of Wady Petra, Stark Co., Ill., *V. H. Chase 1356*, May 26, 1907.

a. Leaf of pubescent *V. sagittata* Ait., south of Wady Petra, Ill., *V. H. Chase 1524*, July 28, 1907.

Aa. *Viola pedatifida*×*sagittata* Brainerd, transplanted, May 3, 1908, from along railway 1¼ miles south of Wady Petra, Ill., *V. H. Chase 1619;* ex horto Middlebury, Vt., Sept. 7, 1909.

1–13. Characteristic leaves of nine F_2 offspring of above hybrid; ex horto (brood 630) October 1909.

PLATE 3

Figures ½ natural size

A leaf of *Viola pedatifida* Don, transplanted, May 1909, from near Galva, Ill., *V. H. Chase 1951;* ex horto (brood 851) Oct. 3, 1911.

A leaf of *V. sororia* Willd., transplanted, May 1909, from Yorkville, Ill., *Mary O. Pollard* coll.; ex horto (brood 707) Aug. 31, 1910.

Hybrid leaf of *V. pedatifida*×*sororia* Brainerd, transplanted, May 1909, from along railway, Stark Co., Ill., *V. H. Chase 1948;* ex horto Aug. 31, 1909.

A.B.—a.b. Characteristic leaves of nine offspring of this hybrid, viz:

A.B, F_3, plant 1 of brood 861, stable as to pubescent palmatifid leaf.
Aa.B, F_2, plant 9 of brood 781, stable as to pubescent leaf only.
a.B, F_2, plant 14 of brood 781, stable as to pubescent uncut leaf.
A.Bb, F_3, plant 8 of brood 868, stable as to palmatifid leaf only.
Aa.Bb, F_2, plant 17 of brood 781, hybrid in both pubescence and form of leaf.
a.Bb, F_3, plant 8 of brood 867, stable as to uncut leaf only.
A.b, F_4, plant q of brood 995, stable as to glabrous palmatifid leaf.
Aa.b, F_2, plant 7 of brood 781, stable as to glabrous leaf only.
a.b, F_4, plant 0 of brood 998, stable as to glabrous uncut leaf.

* United States National Herbarium, *Standley 6072*, near the Sierra Grande 2100–2925 m. alt.), Union Co., New Mex., June 18, 1911.

Viola obliqua Hill and other violets

EUGENE P. BICKNELL

Viola obliqua—the name is become anathema! Venerable indeed, yet from of old misunderstood even by those who have sought to do it honor, rejected, reinstated, and at last altogether cast out, it may be deemed a matter for apology that it should be now once again brought forward. Nevertheless I ask a further hearing in its behalf—the fraternity of violarians must be my judge.

The name seems first to have emerged into the modern light in the Illustrated Flora. If recollection be not at fault, I myself had some part in this. And the view then shared with the author of that work, Hill's illustration before us, that this discredited name was perfectly available for exact use, has not suffered any change. I have not turned to Hill's much ridiculed plate from that day until this writing, nor do I suppose that Doctor Britton has, yet, viewing it together now we are at agreement as before.

More redoubtably than any other writer, more picturesquely, Doctor Greene has used his slings and arrows against this name.* Yet, as his page presently allows us to see, with friendly purpose! His onslaught—assuredly not to be withstood—finally by a hairs-breadth evades a fatal issue. With fine dexterity the all but destroyed thing has been rescued and, on the instant, sent forth with now well-established rights—for how shall it ever again be assailed with better success? Yet somewhere was a miscalculation. Later writers, and there have appeared not a few, have approved the name as extinct, perhaps not stopping to apprehend this reinstatement or the dryness of Doctor Greene's closing avowal " the most common of all East American violets . . . I am confident it can never be proven that it is not *Viola obliqua* Hill."

Doctor Greene has made his hypothetical objector say of Hill's plate that " it does not half represent any violet that ever grew in any country. It is glaringly false in representing flowers erect on

* Pittonia 3: 142–143. 1896.

peduncles perfectly straight to the very summit." Thus is the overtechnical critic at first gaily allowed his fling. But this imagined sceptic need have made less allowance for the "unbotanical draughtsman" than it is implied he should have done. Had Doctor Greene's keen eye ever scanned the woodland floor among the hills along the Hudson, or on Long Island, it must have seen in apparition before it this same pictured violet of Hill's side by side with its living counterpart having flowers postured in the self same upwardly oblique way and even strictly erect! Here then was the living vindication of *Viola obliqua* Hill and Sir John had waited nearly a century and a half to be put in credit. The surprising thing is that his figure ever should have come under any doubt. It utters authenticity. Its entire composition proclaims that it could have been in no part extemporized. Beyond peradventure we see in it the copy of an actual plant worked over by a conscientious but not a facile draughtsman. No inattentive sketch, no artist's fiction, would have been cumbered with the needless and inartistic detail shown in this cut nor, like it, reveal the painstaking effort of a careful but none too practised hand. Nor, as to the flowers should it have been forgotten that Hill put in print, and he had the living plant, that they were "oblique," and Aiton that they were "erect." I do not know whether this violet remained in cultivation in England up to the time when Aiton wrote or whether he had ever seen it in growth. But if his description was drawn up from herbarium specimens having the petals partly discolored from drying it offers an explanation of his use of the word *straminea* in giving the color of the flowers. By fault of this word, nothing else can explain it, the history of the blue-flowered *Viola obliqua* has come confusingly in touch with violets so remotely related to it as the white- or creamy-flowered *Viola blanda* and the yellow-flowered *Viola rotundifolia*.

As for our plant which so perfectly upholds Hill's illustration I doubt not that it may be found bearing its upwardly looking flowers over a far wider range than where I myself have seen it growing, for it is none other than the common violet we have been taught to call *Viola affinis* LeConte. The Illustrated Flora was therefore right in restoring the name *Viola obliqua*, although

not drawing the specific lines so closely as we may now do; Doctor Greene was right in supporting the name with his endorsement; Mr. Pollard in Britton's Manual was exactly right in allowing Hill's name to displace LeConte's. Notwithstanding all this the name *Viola obliqua* will be searched for in vain in the violet writings of the day.

The plant figured by Hill was not that extreme form of the species of slighter figure and narrower leaf that we seem to have set up as typical of *Viola affinis*. But it was of the same flexuous habit, the same grouping of foliage and flower, the same deep cordation and acuteness of the expanded leaf; the blades had the same pronouncedly crenate-serrate marginal pattern, and some of them were quite sufficiently narrow and attenuate to satisfy the most exacting *affinis* standard. It is no objection that other leaves were broadly ovate. Forms of the species, very usual forms, do produce just such broadly ovate leaves and in like way associated on the same plant with the more characteristic narrower ones. Such plants, and others much more strongly grown than the medium plant portrayed by Hill, are not possibly to be kept distinct by a name from the most reduced and delicate forms of the series, for the extreme phases are everywhere inextricably blended together through every avenue of intergradation.

It must not be inferred that there is a particular form of *Viola obliqua* in which the flowers at some stage of their growth always become upturned. This trait of the flower is no more than a tendency in the general species which, in some plants, or colonies of plants, may be perfectly realized, while in others it is not seen at all or proceeds no further than an opening out of the crooked tip of the peduncle causing the flower to stand away from the scape in a horizontal or an upwardly oblique position just as it may in many another violet. Nor is the erect position of the flower at all extraordinary among violets. It is occasionally seen in other species although in no other known to me does it come to a well-established trait, and in no other than this, except rarely, have I seen the flowers strictly "erect or peduncles perfectly straight to the very summit."

Just as our medium plant passes down into its smaller and more delicate forms so also, and with as gradual transformation, does it grow up into an every way larger violet having thicker

leaves, obtuse and of less pronounced crenation, and more striking flowers of deeper hue and bluer tone of color. Of late years much has been made of this larger violet, and forms which cluster about it, under the designation *Viola papilionacea* Pursh.

Let us digress upon this rather ostentatious newcomer among our named violets. For myself I have never quite succeeded in finding out what was the touchstone of "*Viola papilionacea*." Nor does there appear to be perfect accord among its sponsors as to its exact credentials. Mr. Pollard in first taking up the name* introduced us to a wholly glabrous plant, describing accurately the fine violet to which we have just adverted. But the specimens he put out† were at some discord with his description, showing us a violet having a characteristic pubescence on the petioles. In respect of this pubescence the specimens coincide with Doctor Greene's understanding of "*papilionacea*"‡ and with the admirable drawing of Mr. Holm which supplements his description. Mr. Stone, both by description and illustration, reports the plant as bearing pubescence on the petioles.§ Mr. House as well.‖ Doctor Brainerd, on the other hand, although taking a broader treatment, seems more in accord with Mr. Pollard in his description of a wholly glabrous plant** as also is Doctor Dowell††—something like an even division between the smooths and the roughs. All this is not making too much of a little pubescence, for the glabrous and the pubescent plants differ by far more than this one character. And the strain of discrepancy running through the discussions of "*papilionacea*" is reason enough why this conjectural species has not been received by all of us with any such compelling sense of recognition as, for instance, all felt towards "*Viola cucullata*" the instant that Doctor Greene gave us the cue.

The glabrous "*papilionacea*" is found on grassy banks or at the borders of meadows along descending places from woodlands

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* Bot. Gazette **26**: 136. 1898.

† North Am. Violaceae. Determined and distributed by Prof. Edward L. Greene and Mr. Charles Louis Pollard, No. 8.

‡ Pittonia **4**: 140–141. 1900.

§ Proc. Acad. Nat. Sci. Phila. **55**: 670–671. 1904.

‖ Bull. Torrey Club **32**: 258. 1905.

** Rhodora **6**: 15. 1904; Bull. Torrey Clu **3** : 590. 1910.

†† Bull. Torrey Club **37**: 164. 1910.

where *Viola obliqua* grows. In these near meadows or by brooks that traverse the same woodlands "*Viola cucullata*" raises its long-stemmed flowers of twofold blue. In many ways the smooth "*papilionacea*" is strikingly intermediate between these two plants. Doctor Brainerd has opened our eyes to violet hybrids. Have we not found one here? I recall all these violets as they grew in profusion about my former home on the Hudson and seem to see, I did not see it then, our woodland and our meadow violet meeting in such places as I have described and crossing over into each other—how else than through free hybridization? And the perplexing intermediate examples that I had then tried to sort into species seem, as the specimens are turned to now, to lend strong confirmation to such an hypothesis. If, then, we have indeed here come upon the truth, our "*papilionacea*" is seen to be not all that we have been asked to believe. Yet by this very reduction it takes a clearer outline as a plant marked by a characteristic hairiness on the convex side of the petiole, often localized just below the blade, but often, also, thinly diffused on the lower surface of the lamina, precisely as Mr. Holm's drawing so faithfully portrays. The upper face of the blade is by no means always glabrous, but what pubescence may later appear there is not often very obvious. By this at first strictly dorsal pubescence it is a marked plant, for it should be noted of the glabrous "*papilionacea*"—whether the hybrid, if so it proves to be, or the enhanced *Viola obliqua*—that the slight pubescence it may sometimes show has its site on the upper surface of the blade just where we find evidences of it in the nearly glabrous *Viola cucullata*. It is a marked plant also, in its group, by deeply cordate and crenate-dentate leaves which in age so open out their cordation as to become subtruncate at the base, and it is an especially noteworthy violet by reason of a ready tendency to semi-domestication.

It will be well here to turn to yet another one of our violets, the pubescent *Viola sororia* Willd. In woodlands wherein this species and *Viola obliqua* are in free growth together they may be found, it is no uncommon thing, blending the one into the other in perfect confluence. Among these plants of mixed strain we recognize, now *Viola obliqua*, changed only by the beginnings of

pubescence, now its too intimate associate, still to be called *Viola sororia* but taking a more gracilent habit and narrower form of leaf. More intermediate in the series are plants of stronger growth and in these we seem to see our pubescent "*papilionacea*," never, perhaps, exactly as we know it in its semi-domesticated state but so much the same that the origin of our plant would seem to be disclosed as though in an open book. We have been here freely following appearances and may have been easily mislead in thus seeming to have traced our plant back to the mode of its beginning. Nothing like demonstration has assured us. But, if it were indeed a proved thing, even then our semi-domesticated "*papilionacea*," far along in its generations, would be manifestly of a higher category than those chance hybrids we seem to come upon in the making. Our plant thrives in places whence both of its suggested parents have disappeared, or perhaps have never been. It is become independent of the parental aid, is self perpetuating. It is, by continuous descent from season to season, no longer a hybrid, but rather a species whose hybrid origin goes back —how far we may not know. Such a plant is surely to be accorded its own distinctive name. I have not found that such a name has ever been given unless the pleasing one *Viola laetecaerulea* of Doctor Greene may happily prove to be available.

Most certainly we cannot continue to call this plant *Viola papilionacea* Pursh. We turn to Pursh and read under this name, it is so clear we cannot be mistaken, the quite sufficient description of no other violet than our common one of boggy meadows and wet places that we have been calling *Viola cucullata* Aiton. Of this violet there is an open meadow form, it has doubtless been remarked by all of us who have given any field attention to violet matters, that has definable points of difference from more usual phases of the plant and this, may we not say unmistakably, is the form more particularly held in view by Pursh. In my collections formerly made about Van Cortlandt Park I find specimens of this plant put aside as far back as 1895 under a herbarium name given with reference to the notably triangular cordate and acute leaves well-developed as early as the time of flowering. The leaves are not strongly cucullate nor strictly glabrous nor is their marginal pattern at all pronounced ("*triangu-*

laricordatis acutis crenatis subcucullatis glabriusculis"—Pursh's description could scarcely be more exact); the peduncles, at flowering, little if at all surpass the leaves in height (*pedunculis longitudine foliorum*); the flowers, compared with those of the *Viola obliqua* series, are explicitly more papilionaceous, allowing for the fanciful application of this adjective to the flower of a violet, ("*petalis obovatis: 3. inferioribus infra medium barbatis conniventibus, 2. superioribus reflexis*").* Point by point Pursh's description meets the distinctive characters of this plant, proving slightly inexact only in respect of the variable bearding of the petals, for the odd one, although sometimes slightly bearded, is prevailingly glabrous. The bearding dusted with pollen readily becomes Pursh's "yellow down." "Flowers blue, elegantly striated," points with unmistakable indication to the flowers of our meadow violet distinguished above all others by the delicacy and sharp beauty of their dark penciling. "In wet places" would scarcely be particularly affirmed of any other blue-flowered heart-leaved violet, although Pursh does say of his other one "In grassy wet places," wherein, however, is more of a distinction than might appear to one not well knowing our violets in the places where they grow. Upon the face of the evidence this other violet of Pursh's, his "*Viola cucullata* Ait.," was our *Viola obliqua*. Its glabrous leaves, cucullate only at the base, had more prominently indentured margins than the crenate leaves of his *Viola papilionacea*, he expressed the difference by calling them "serrate"; the scapes were shorter, an essential distinction; the petals were obliquely bent, therefore the upper pair less characteristically reflexed and the others more open. The two plants are thus placed by Pursh in unmistakable apposition. The lateral petals are described as being merely "bearded," not, as in his *papilionacea*, "*infra medium barbatis*," an acute distinction, not to bear a too literal rendering, but quite true in the sense that the bearding in the one species is more restricted and relatively more basal on the petal than in the other. Mr. Stone is, I think, the only recent writer who has called attention to the more forward extension of

* It should be said that this description applies more particularly to the flower in its earlier and its later stages—I know of no violet the flower of which at the stage of fullest development is not more or less widely expanded.

the bearding in *Viola obliqua*—his *Viola affinis*.* "Flowers blue, white at their base," points also to *Viola obliqua* for, while the *petals* of all these violets are white at their base, the *flowers* of this one are lighter towards the throat where those of our "*cucullata*" are characteristically of deeper hue, often in sharp contrast with the pale blue surrounding parts.

It is not to be believed that Pursh did not know both of these common violets, and I have been at pains to determine and to lay stress upon each of his described species the better to emphasize the identity of his *Viola papilionacea*, for it would appear that by right of priority this is the true name of our meadow violet that we have been miscalling *Viola cucullata* Ait.

If a decade and more ago we knew as much about our violets as we know today, however scant our present knowledge may be, Aiton's *Viola cucullata* would scarcely have been construed in terms of our meadow violet that, as we have just seen, Pursh called *Viola papilionacea*. Doctor Greene in pointing out to us this distinct but long hidden species did not adopt for it a doubtfully applicable name without using a deliberate mark of interrogation.† However unmistakable the description of any later author may be, there is not one word by Aiton himself that can be deemed distinctive of this plant. Quite otherwise. His *Viola cucullata* had, for instance, subterete scapes shorter than the leaves, which were attenuate at the apex, and the petals, the upper pair not being reflexed, were white at their base. His entire description differs in no essential from the description of Hill's *Viola obliqua*, nor does it fail at any point to apply to that plant. That species must have been the very one he had before him but, believing Hill's plant to be characterised by erect flowers, partly stramineous in color like some of the European species, he very naturally considered his own plant to be distinct by reason of blue inverted flowers on scapes reflexed at the apex, which characters, although common to all violets, he is particular to report. Can it be doubted that the name *Viola cucullata* Aiton is but a synonym of *Viola obliqua* Hill and that our meadow violet that we have allowed to bear Aiton's name should now inherit from Pursh the name *Viola papilionacea?*

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* Loc. cit., p. 671.

† Pittonia 3: 143. 1896.

Yet another violet should here receive a word. Little recognition has been accorded to *Viola domestica*. I ask myself, Can it be alone from force of first impressions that this violet remains to me one of the most individualized and set apart species of its group? No other one is altogether glabrous. I have given the closest scrutiny to very many growing plants and failed to detect on even one so much as a single hair. Rare examples viewed by lens do show some obscure appressed spiculae near the margin of the leaf on its upper face, but such plants are so unusual as to suggest some admixture in the strain. By this rather remarkable absence of pubescence this violet is at marked variance from the one that has been combined with it under "*papilionacea*," in which some dorsal hairiness on the leaf is so constant a character. There is other evidence that these two violets are of collateral rather than lineal relationship. In more than one direction they disclose an obviously different course of growth. In the pubescent one, I know not what other name to call it by than *Viola laetecaerulea* Greene, the scapes at flowering are erect, bearing the flowers high, even above the leaves, later becoming flexuous or sometimes declined; in *Viola domestica* they are always shorter than the leaves and tend to rise obliquely, sometimes bearing the flowers out around the sides of the tuft. The light green leaves of *Viola laetecaerulea* at flowering time are normally deeply cordate, later becoming dilated and taking a more or less subtruncate base; those of *Viola domestica* are from the first openly cordate or subtruncate and show much less change of form with age. They are of a strikingly bright deep green and when young somewhat succulent and shining. The flowers are unlike those of *Viola laetecaerulea*, or any other violet known to me, having longer more twisted often narrowly rhomboid petals of deeper hue intensifying into a dark true purple. The upper pair when in ultimate position are not only reflexed but deflexed backward by a downward twist from the base. *Viola laetecaerulea* is one of our earliest flowering blue violets, *Viola domestica* the latest of all. While the former is partly domesticated the latter must be, I think, considered as wholly so. It is found by fence rows, in old orchards, yards and abandoned grounds, growing in rich but never in wet soils and in shade or partial shade as if it had come originally from

the woods. But I have never found it in a really wild state, that is to say, never far away from the habitations of man. It is of more gregarious habits than any of our wild species, often colonizing so thickly over wide spaces as to crowd out most other plants and, until taking its strong later growth, is low and somewhat spreading of leaf and peduncle, keeping close to the ground; not least to be noted is its relatively narrow range of variation, which is unusual among the violets of its immediate relationship. It has been classed with "*papilionacea*", although its nearest ally is doubtless *Viola obliqua;* but it is too signally different from that species to be forced upon it. Because hybridization may have at some period entered into the history of *Viola laetecaerulea*, of domestic tendencies, there might be reason for inquiring whether *Viola domestica* had not a like origin, but, if *Viola obliqua* is or was one parent, where is the other?

Should the indications reported in this paper not be mistakenly understood the facts before us would be these: That the name *Viola obliqua* Hill belongs to the common and widely variable violet that we have been calling *Viola affinis* LeConte. That no such species exists as the supposed one we have been calling "*Viola papilionacea*," this being a mixture, partly an accentuated phase of *Viola obliqua*, partly a hybrid of that species with our meadow violet, partly also a cross of *Viola obliqua* with *Viola sororia* and partly a well appointed violet, perhaps descended from such a cross, which may be called, pending proof, *Viola laetecaerulea* Greene. That the *Viola cucullata* of Aiton is a synonym of *Viola obliqua* Hill, and that our meadow violet that we have known as *cucullata* was first described by Pursh, receiving the inalienable name *Viola papilionacea.* That *Viola domestica* is, by attributes of form and habit, invested with a signal individuality and that notwithstanding its domesticated nature the source of its origin does not yet appear.

NEW YORK

Observations on the inception, season, and duration of cambium development in the American larch [Larix laricina (Du Roi) Koch.]*

L. Knudson

(with plates 18 and 19)

Introductory

During the past twenty-five years very little attention has been devoted to a minute study of the diameter increase in trees. Comparatively little is known concerning the season of wood formation; and with respect to the region of the tree in which diameter increase first begins, the evidence is contradictory. With the object of determining the part of the tree in which cambial activity begins, as well as to determine the season of growth, investigations were begun during the season of 1909 and continued in 1911. The results obtained from the study of material collected these two seasons form the basis of this paper.

The subject was suggested by Prof. W. W. Rowlee, and to him, as well as to Prof. B. M. Duggar, the writer is indebted for helpful suggestions.

Historical

The work of von Nordlinger, Th. Hartig, Robt. Hartig, Mer, and others has thrown some light upon the extent and duration of cambial activity. They have found, in general, that under forest conditions growth first begins in the youngest twigs and then proceeds downward into the older regions. Less work has been done on the cambial activity in isolated trees.

Concerning the region of first cambial activity, Th. Hartig† concluded that it occurred in the youngest twigs and then gradually extended downward. In a 30-year old *Pinus sylvestris*, and also in oak, cambial activity began almost simultaneously over the entire trunk, while in larch and maple of the same age cambial

* Laboratory of Plant Physiology, Cornell University, Contribution No. 8.

† Hartig, T. Anatomie und Physiologie der Holzpflanzen, 368. 1878.

activity began from two to four weeks later in the lower part of the trunk than in the twigs.

As a result of extensive investigations, Robt. Hartig* advanced the idea that cambial awakening was dependent upon temperature and that therefore the thickness of the bark, temperature of the soil moisture, and insolation, were important factors. He found in an isolated 10-year old *Pinus sylvestris*, that cambial activity had begun two weeks earlier than in isolated 35- and 65-year old trees, and four weeks earlier than in a 100-year old tree grown under forest conditions. The comparisons were all made at a height of 6 meters. He also found that under natural forest conditions the growth of the annular ring of Scotch pine, Norway spruce, and European larch at a height of 27.5 meters, was on June 9 respectively 66 per cent, 56 per cent and 75 per cent completed. Going toward the base the growth decreased, and at a height of 1.5 meters the percentage of the annular ring completed was 35, 21 and 18 per cent respectively. In isolated trees of Scotch pine and Norway spruce the growth on July 9 was approximately the same in all parts of the trunk. Under forest conditions growth was found to begin in the twigs and proceed downward, the cessation of growth following the same order.

According to Mer,† the cambial activity in oak, beech, basswood, fir, and other trees of twenty-five years of age and under begins in the youngest twigs. In older trees cambial activity is described as simultaneous at the bases of the branches and trunk. He states also that in a single cross-section cambial activity may be evident on one side and not on another.

Hastings‡ found that in broad-leaved trees increase in diameter did not begin until the buds had opened. He found that growth first begins in the 1-year old twigs, and later it occurs in 2- and 3-year old twigs. When wood is forming in 5- or 6-year old growth there is simultaneous development over the entire tree. In pine it begins first in the 2- and 3-year old twigs. In the hemlock the growth was first observed in the 6-year old twigs,

* Hartig, R. Das Holz der deutschen Nadelwaldbäume, 35–38. 1885.

† Mer, E. Sur les causes de variation de la densité des bois. Bull. Soc. Bot. France **39**: 95–105. 1892.

‡ Hastings, G. When increase in thickness begins in our trees. Science II. **12**: 585. 1900.

while in *Taxodium distichum* the same conditions prevail as in the broad leaves.

Buckhout* made during a period of four years caliper measurements of European larch at intervals of five days during the growing season. The measurements were made at breast height and the age of trees experimented upon is given as 45 years. He found that the formation of leaves was coincident with the beginning of diameter increase. The beginning of this increase was close to April 25, during the four years. He found a gradual increase from this date until about July 1, when further growth in diameter practically ceased. The data secured from this method of measurement are not, as he himself realized, entirely conclusive, on account of the errors which may result from the swelling and shrinking of wood and bark with the varying moisture content.

From the horticultural side gross investigations have been made by Keffer,† Goff,‡ Cranefield,§ and others on the duration of growth in fruit trees. Their work is concerned with the development of shoots and on the duration of wood increase as determined by the readiness with which the bark could be peeled. The work of these men will be considered in a subsequent paper.

METHODS OF INVESTIGATION

For the investigation during 1909, four larch trees of approximately thirteen years of age were used. These trees are hereafter designated for convenience as trees *A*, *B*, *C*, and *D*. The trees originally grew in a swamp in Oswego County, New York, but were transplanted in 1902 to the nursery on the Cornell University Campus, on land which slopes gently to the west and is of a well-drained, heavy clay soil type. The trees were planted four feet apart and were shaded on the east and west sides but not on the

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* Buckhout, W. A. The formation of the annual ring of wood in European larch and the pine. Forestry Quarterly **5**: 259–267. 1907.

† Keffer, C. A. The early growth and training of apple trees. Tenn. Agr. Exp. Sta. Bull. **14**: 1–16. 1901.

‡ Goff, E. S. The resumption of root growth in spring. Wisconsin Agr. Exp. Sta. Ann. Rep. **15**: 220–228. 1898.

§ Cranefield, F. Duration of growth period in trees. Wisconsin Agr. Exp. Sta. Ann. Rep. **17**: 300–308. 1900.

north or south. Trees *B*, *C*, and *D* were very uniform as regards size and form. Tree *A*, although of the same age, was slightly smaller.

In order to determine the region of growth inception it was necessary to take material from the apex of the tree to the base. The larch has, at intervals, whorls of branches, the number of which agree approximately with the age of the tree. The trees used had each ten such whorls and material was removed from below each whorl, at different times throughout the growing season. Cuttings were made only from the south side of each tree. The first cuttings were made a few inches below each whorl of branches and the subsequent cuttings were made a few inches below the preceding and a little to one side. In obtaining the material for study two incisions, 2 cm. apart, were made through the bark and into the wood to a depth of 1 cm. and the piece then removed with a small knife. The injured area was then filled with grafting wax.

The material collected from trees *A* and *B* was fixed in a solution consisting of 33 parts glycerine, 35 parts alcohol, 30 parts distilled water, and 2 parts glacial acetic acid. The material kept in this solution was in excellent condition for sectioning, though, of course, no good fixing of the protoplasmic structure was obtained. That collected from trees *C* and *D* was fixed in Gilson's solution and kept, by mistake, in 95 per cent alcohol. When attempts were made to section it, several months later, considerable difficulty was experienced, because of brittleness. Attempts to soften the material, by allowing it to remain in equal parts of glycerine and alcohol, and also in glycerine alone, proved futile. The greater part of the material was sectioned without imbedding, but some of it was necessarily imbedded in celloidin. The sections were cut from 20 to 40 μ in thickness and stained with safranin and Delafield's haematoxylin of the formula so commonly used for wood staining. The methods employed during the season of 1911 are described subsequently.

INVESTIGATIONS OF 1909

The first cuttings were made on April 19 and at this time the buds located on the 4-, 5-, and 6-year old wood had opened,

the leaves being 1/16 of an inch in length. On the younger wood, the buds were less advanced. This was more marked in the 1- and 2-year old wood. This slower development toward the terminal shoot and apex of the branch held true also for the catkins. The same condition was noted also in several larches which in September produced a new growth of leaves, the result of a drouth, followed by favorable conditions. This earlier development of leaves on the older wood is significant in the light of the subsequent facts concerning the inception of cambial activity.

Cambium in resting condition.—According to Sanio and other investigators the cambium proper consists of a tissue but one cell in thickness, which cells by division produce a row of xylem mother and a row of phloem mother cells. Each of these rows divides and gives rise respectively to two rows of potential xylem cells and two rows of potential phloem cells. Except by careful cytological study the row of true cambium cells cannot be distinguished from the neighboring cells. The term cambium has been, therefore, generally applied to that tissue which lies between the visibly differentiating phloem and xylem. The cambium tissue is composed of a number of rows of cells, which cells are characterized by their thin walls, dense protoplasmic content, and, viewed in cross section, rectangular shape. In trees in the resting condition it would be reasonably assumed that the true cambium comprises the first row of cells just without the xylem. The cells bordering this row on the outside would then be considered as phloem. As a matter of fact, however, sections made from cuttings obtained from the trunk of larch on November 13 exhibit just outside of the xylem a distinct tissue 34 μ in diameter, consisting of five or six rows of cells in thickness. The cells of the outer five rows are not visibly distinguished from cells of the inner row, but are distinguished from the adjacent phloem cells by their size and protoplasmic content. See FIG. 1 and 3. Because of the similarity of all of these cells I have considered the six rows as comprising the cambium tissue, the term cambium being employed in its generally applied sense.

Inception of cambial activity and development of phloem.—The material collected on April 19 showed that cambial activity had begun. The layer of six cambium cells had increased in diameter.

The outer cells of this tissue were losing their rectangular shape and assuming more nearly that of a square, as viewed in a cross section. See FIG. 1, 2, and 3. In studying the slides made from material collected on April 19, it was found that in the 5th, 6th, and 7th cuttings of tree *A* the cambium had developed to a greater extent than in the other cuttings. Not only had the cambium increased in diameter, but seemingly new cells had been formed. This increased development near the middle was maintained until May 25. The average increase in number of phloem cells by May 25 was only 1.8, but the diameter increase of the cambium and phloem was nearly 100 per cent. Up to this time no xylem whatsoever had been developed. It appears therefore that the earliest growth consists in an enlargement of the cambium tissue with the gradual transformation of the peripheral cells into phloem tissue. The old phloem cells adjacent at this time are becoming compressed due to the pressure brought about by the transformation of the cambial cells. Compare FIG. 1, 2, and 3.

In TABLE I are given the figures obtained by the measurement of the diameter of phloem and cambium tissues in trees *A* and *C*. The figures for the diameter of the cambium tissue during the resting period (cutting made November 13) are given for comparison. The figures included under the dates April 19 to May 25 inclusive refer to tree *A*. From June 3 to July 6 the figures refer to tree *C*.

As indicated previously, the six-celled layer adjacent to the xylem is considered the cambium. Although transformation of the peripheral cells had occurred, it is difficult to state which cells are cambium and which cells are phloem. Consequently the six rows, despite the transformation, I have considered as cambium. Any cells in excess of the six rows, which lie within the old compressed phloem cells, I have considered as new phloem. After May 25, when xylem and phloem were both developing rapidly, the cambium tissue was still considered as a tissue of six rows of cells. It was difficult to select always the six most uniform rows, but in general the error was slight and at most of little consequence.

From an examination of the table it may be seen that up to May 25 the middle regions show the greatest growth. From April 19 to May 25 the increase in phloem was gradual, but from May 25

TABLE I

NUMBER OF ROWS OF NEW PHLOEM CELLS AND DIAMETER OF PHLOEM AND CAMBIUM TISSUE IN TREES *A* AND *C*

Region of cutting	Nov. 13		Apr. 19		Apr. 26		May 5		May 11		May 25		June 3		June 15		June 30		July 6	
	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ
Below 1st whorl	0	34	0	34	0	34	0	41	0	58	0	51	7	122	7	146				
Below 2d whorl	0	34	0	54	0	58	1	51	0	58	0	51			9	170				
Below 3d whorl	0	34	0	58	1	68	0	58	0	51	4	75			10	184	12	224		
Below 4th whorl....	0	34	2	58	1	61	0	51	2	68	4	75	10	187	8	184	15	296		
Below 5th whorl....	0	34	1	68	2	71	2	71	3	74	3	85	11	204	9	177	14	278		
Below 6th whorl....	0	34	2	61	1	68	2	74	2	71	3	75	12	221	9	211	14	273		
Below 7th whorl....	0	34	1	68	1	65	1	58	1	68	2	61	11	207	9	191	13	262		
Below 8th whorl....	0	34	0	58	0	48	1	51	1	61	2	58	14	190	14	211	14	278	15	278
Below 9th whorl....	0	34	0	44	0	51	0	51	1	54	0	51	—		11	208		—	16	289
Below 10th whorl...	0	34	0	44	0	51	0	44	0	51	0	51	12	204	10	204		—	12	238
Average.....	0	34	0.6	54.7	0.6	57.5	0.7	55	1.	61.4	1.8	63.3	11	190.7	9.6	189	13.6	268	14.3	268

to June 3 the growth was markedly increased, while from June 3 to June 15 seemingly little growth occurred. After June 3 it appears that relatively few new phloem cells were formed, but growth consisted more of an enlargement of the cells already formed. Some of the figures for June 15 are less than the corresponding figures for June 3. This may be perhaps explained by the fact that the cuttings were made somewhat lower, or better perhaps by the fact that in obtaining these cuttings they were not taken on a line directly below the preceding, but to one side. Mer (loc. cit.) draws special attention to the well-known observation that wood growth is not always uniform on all sides of the tree.

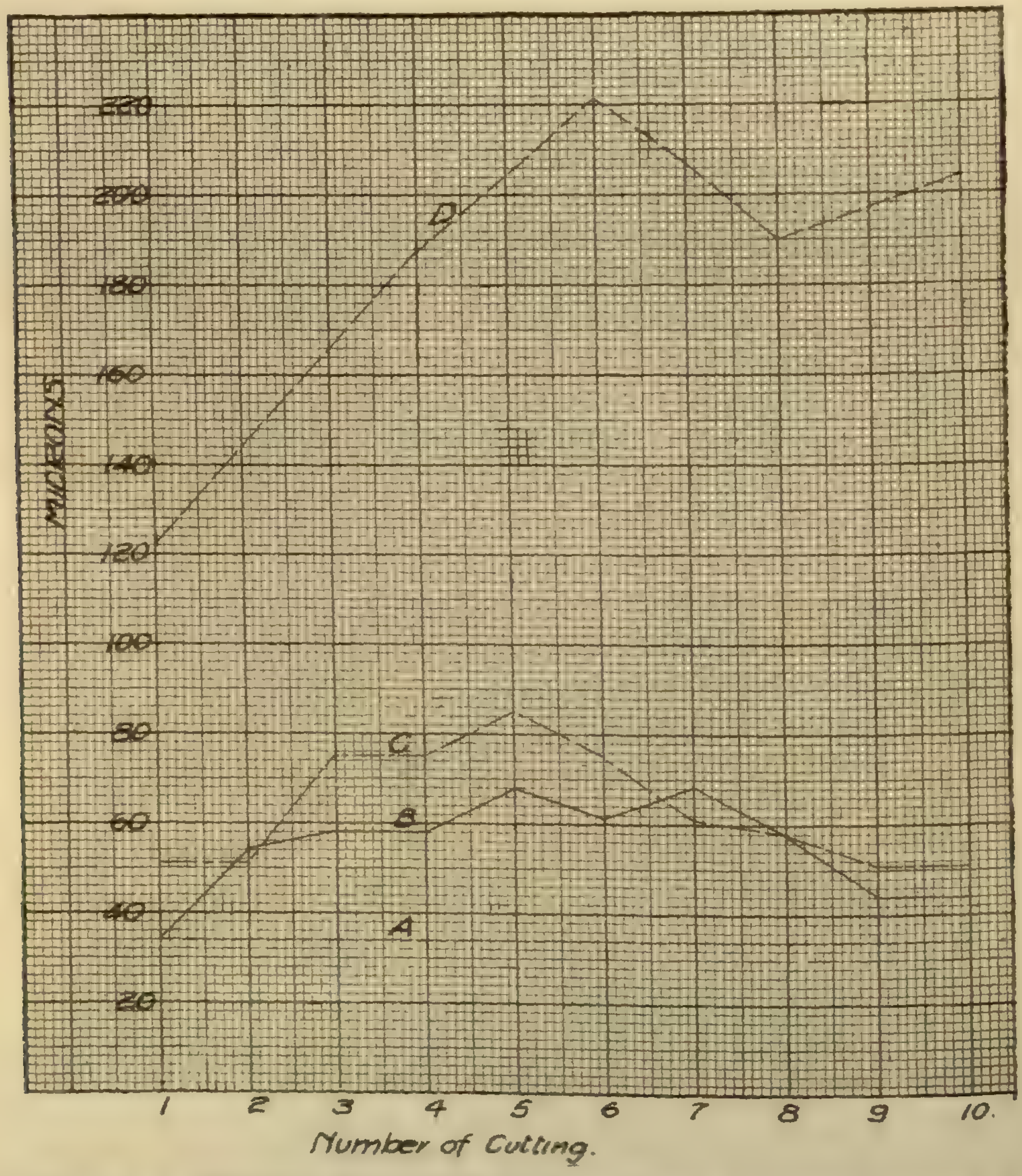

DIAGRAM 1. Diameter of cambium and new phloem at various different dates. *A*, Nov. 13; *B*, April 19; *C*, May 25; *D*, June 3.

By July 6 the phloem was nearly complete with respect to cell numbers; for, the average annual number of rows of phloem cells produced during a period of three years was found to be seventeen. At this time the cells were all very regular in form and no visible differentiation had occurred. In DIAGRAM I are represented the diameter measurements of the phloem at several different dates.

In trees *B* and *D* the growth is similar to that in trees *A* and *C*, though more vigorous growth resulted in tree *B* than in tree *A*. In this tree also the development of cambium consists first in a transformation of the peripheral cells. In this case, however, the number of rows of phloem cells produced by May 25 was 5.6 with nearly a 200 per cent increase in diameter. The detailed figures are given in TABLE II.

TABLE II

NUMBER OF ROWS OF NEW PHLOEM CELLS AND DIAMETER OF PHLOEM AND CAMBIUM TISSUES IN TREES *B* AND *D*

Region of cutting	Nov. 13		May 5		May 11		May 25		June 8		June 18	
	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ
Below 1st whorl.....	0	34	—		—	75	2	68	8	170	11	228
Below 2d whorl	0	34	0	34	3	58	4	122	11	193	11	218
Below 3d whorl	0	34	3	68	4	82	4	76	—	—	11	286
Below 4th whorl.....	0	34	4	102	4	102	6	92	12	221	14	262
Below 5th whorl.....	0	34	5	85	6	115	—	—	—	—	12	262
Below 6th whorl.....	0	34	4	68	8	107	7	92	10	190	13	238
Below 7th whorl.....	0	34	—	—	4	85	7	102	—	—	14	279
Below 8th whorl.....	0	34	4	85	—	—	6	92	8	170	—	—
Below 9th whorl.....	0	34	2	61	—	—	6	76	8	173	12	245
Below 10th whorl....	0	34	3	75	—	—	6	—	—	—	11	238
Average.....	0	34	3.1	72	4.8	89	5.3	90	9.5	186	12	250

Development of xylem.—While in tree *A* there was a gradual increase in phloem from April 19 to May 25, yet no xylem cells had been formed. During the week of May 25 to June 3, coincident with the marked increase of phloem, a very marked increase of xylem occurred, over one third of the xylem being completed during these seven days. TABLE III gives the figures obtained for the number of rows of xylem cells formed, and the diameter of the xylem tissue in the various cuttings at the different dates. There is included also the diameter of the xylem tissue formed in tree *B* during the years 1909 and 1910. In the first column the

figures refer to tree *A*. The figures from June 3 to July 6 refer to tree *C*.

TABLE III

NUMBER OF ROWS OF NEW XYLEM CELLS FORMED AND DIAMETER OF NEW XYLEM TISSUE IN TREES *A* AND *C*

Region of cutting	May 25	June 3		June 15		June 30		July 6		1909	1910
	No.	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	Dia. μ	Dia. μ
Below 1st whorl . .	0	15	262	25	544	43	1,054			646	986
Below 2d whorl . .	0			33	833	55	1,564			1,598	1,377
Below 3d whorl . .	0	20	578	33	918	48	1,462			1,853	1,870
Below 4th whorl . .	0	29	697	43	1,122	50	1,462			1,785	1,870
Below 5th whorl . .	0	28	748	45	1,292	55	1,530			1,360	1,955
Below 6th whorl . .	0	23	646	46	1,326	58	1,666			1,275	1,224
Below 7th whorl . .	0	24	648	36	1,122	57	1,515			1,734	1,428
Below 8th whorl . .	0	22	714	36	1,156	57	1,632	65	1,972	2,363	1,598
Below 9th whorl . .	0	—	697	28	850		—	62	1,870	1,666	1,088
Below 10th whorl .	0	20	663	27	833	58	1,564	58	1,802	—	—
Average	0	22.5	628	35.2	999.6	53.3	1,493	61.6	1,881	1,586	1,488

From the table it cannot be determined exactly in which part of the tree xylem growth first begins. The greatest growth by June 3 was below the fifth whorl of branches while the least growth was just below the first whorl of branches. In general, by June 3 more xylem cells were formed in the middle of the tree than at either the top or base. This would tend to indicate that the first growth of xylem occurred in the middle of the tree below the fifth whorl of branches.

TABLE IV

NUMBER OF ROWS OF NEW XYLEM CELLS AND DIAMETER OF NEW XYLEM TISSUE IN TREES *B* AND *D*

Region of cutting	May 11	May 25		June 8		June 18	
	No.	No	Dia. μ	No.	Dia. μ	No.	Dia. μ
Below 1st whorl	0	0	0	22	442	43	1,003
Below 2d whorl	0	0	0	40	647	53	1,326
Below 3d whorl	0	0	0	—	—	55	1,394
Below 4th whorl	0	4	51	35	918	50	1,258
Below 5th whorl	0	—	—	—	—	45	1,292
Below 6th whorl	0	5	55	32	850	46	1,122
Below 7th whorl	0	2	20	—	—	55	1,258
Below 8th whorl	0	0	0	34	850	—	—
Below 9th whorl	0	0	0	30	782	50	1,292
Below 10th whorl	0	0	0	—	—	49	1,292
Average	0	1.2	14	32	748	49	1,248

TABLE V

TOTAL NUMBER OF ROWS AND DIAMETER INCREASE OF PHLOEM, CAMBIUM, AND XYLEM CELLS IN TREES *A* AND *C*

Region of cutting	Nov. 13		Apr. 19		Apr. 26		May 5		May 11		May 25		June 3		June 15		June 30		July 6	
	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ
Below 1st whorl. . . .	6	34	5	34	5	34	7	41	7	58	6	51	28	384	38	690	—	—		
Below 2d whorl	6	34	6	51	7	54	6	51	6	58	6	51	—	—	48	1,003	—	—		
Below 3d whorl	6	34	6	51	6	58	6	58	6	51	10	75	—	—	49	1,101	66	1,686		
Below 4th whorl. . . .	6	34	8	68	6	62	8	51	8	68	10	75	45	884	58	1,305	71	1,758		
Below 5th whorl. . . .	6	34	7	61	8	71	9	71	9	68	9	85	45	952	60	1,468	75	1,741		
Below 6th whorl. . . .	6	34	7	75	8	68	8	75	8	71	9	75	41	867	62	1,536	78	1,945		
Below 7th whorl. . . .	6	34	7	58	7	65	7	58	7	68	7	61	41	853	53	1,312	76	1,842		
Below 8th whorl. . . .	6	34	6	51	7	48	7	51	7	61	7	58	42	935	56	1,332	77	1,910	86	2,251
Below 9th whorl. . . .	6	34	6	44	6	51	7	51	7	54	6	51	—	—	45	1,057	—	—	84	2,125
Below 10th whorl. . .	6	34	6	44	6	51	6	51	6	51	6	51	38	867	43	1,037	—	—	76	2,040
Average	6	34	6.4	53.7	6.6	56	7.1	55.8	7.1	60.8	7.5	63.3	40	820	51.2	1,184	73.8	1,813	82	2,138

While in trees *A* and *C* the region of the first growth of xylem could not be definitely located, more fortunate results were obtained with tree *B*. No xylem was formed in tree *B* until May 25 and then neither at the top nor at the base of the trunk, but in the middle region. By May 25 then the xylem in that part of the tree between the fourth and fifth whorls of branches was four cells in thickness,—while between the sixth and seventh whorls it was five cells and between the seventh and eighth it was two cells in diameter. The most marked development again occurred immediately after May 25. The detailed figures are given in TABLE IV.

Season and duration of diameter increase.—In order to bring out more clearly the period of greatest diameter increase, the combined values for increase of phloem, cambium, and xylem, in trees *A* and *C* are given in TABLE V.

From the table it is at once evident that very little growth took place previous to May 25, and the growth which occurred was confined, as before indicated, entirely to the cambium and phloem. From May 25 to June 3 a very marked increase occurred, and during that time in the middle regions of the trunk nearly one half of the total diameter increase was completed. In TABLE VI is given the daily average increase in rows of cells and also the daily diameter increase in trees *A* and *C*.

TABLE VI

Period	May 25–June 3	June 3–June 15	June 15–June 30	June 30–July 6*
No. rows of cells.....	4.2	1.	1.4	1.
Dia. in microns.....	94.5	30.	40.	48.

By July 6 the ring of xylem was almost complete, judging from the extent of the summer wood which was then in the process of formation, though not yet completely developed. Unfortunately no further series of cuttings were made after July 6 to determine the succession with regard to growth cessation.

In TABLE VII is given the combined diameters of the phloem, cambium, and xylem tissue in trees *B* and *D*, as well as the total number of cells.

* For cutting nos. 9–10 only.

TABLE VII

TOTAL NUMBER OF NEW ROWS AND DIAMETER OF PHLOEM, CAMBIUM AND XYLEM CELLS IN TREES *B* AND *D*

Region of cutting	Nov. 13		May 5		May 11		May 25		June 8		June 18	
	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ	No.	Dia. μ
Below 1st whorl....	6	34	—	—	10	75	8	68	36	612	60	1,231
Below 2d whorl....	6	34	6	34	9	58	11	89	57	840	70	1,544
Below 3d whorl....	6	34	9	68	10	88	10	75	—	—	72	1,680
Below 4th whorl...	6	34	10	102	10	102	16	143	53	1,071	70	1,520
Below 5th whorl....	6	34	11	85	14	115	—	—	—	—	63	1,486
Below 6th whorl....	6	34	10	68	15	108	18	147	48	1,040	65	1,506
Below 7th whorl....	6	34	—	—	11	85	14	122	—	—	77	1,537
Below 8th whorl....	6	34	10	85	—	—	12	92	48	986	—	—
Below 9th whorl....	6	34	8	61	—	—	12	76	44	955	68	1,537
Below 10th whorl...	6	34	9	75	—	—	—	—	—	—	62	1,530
Average.....	6	34	9	72	11	90	12.6	101.5	47.5	917	69.4	1,508

The season of diameter growth in larch is relatively short. Practically all of the growth occurred during the month of June. The small increase produced from the time of bud opening, April 19 to May 25, consisted entirely of cambium and phloem development. The diameter increases of trees *A* and *C* and *B* and *D* during the season 1909 are graphically represented in DIAGRAM II.

INVESTIGATION OF 1911

Since the studies made in 1909 indicated that growth in diameter first occurred in the middle region of the trunk and not at the base or apex, it seemed advisable to continue these studies with respect to the development in the lateral branches. The investigation was made with the object of answering the three following questions: (1) Does inception of diameter increase begin first in the topmost branches, in the middle, or in the basal, branches? (2) In what part of the individual branches does diameter increase begin? (3) Does xylem development in the lateral branches precede that in the trunk?

For this investigation a larch tree of approximately 10 years of age was used. It was growing isolated, about 100 feet from the trees mentioned above, growing in the nursery row. For convenience this tree is hereafter designated as tree *E*. On May 22, from each of the whorls of branches from apex to base, one branch

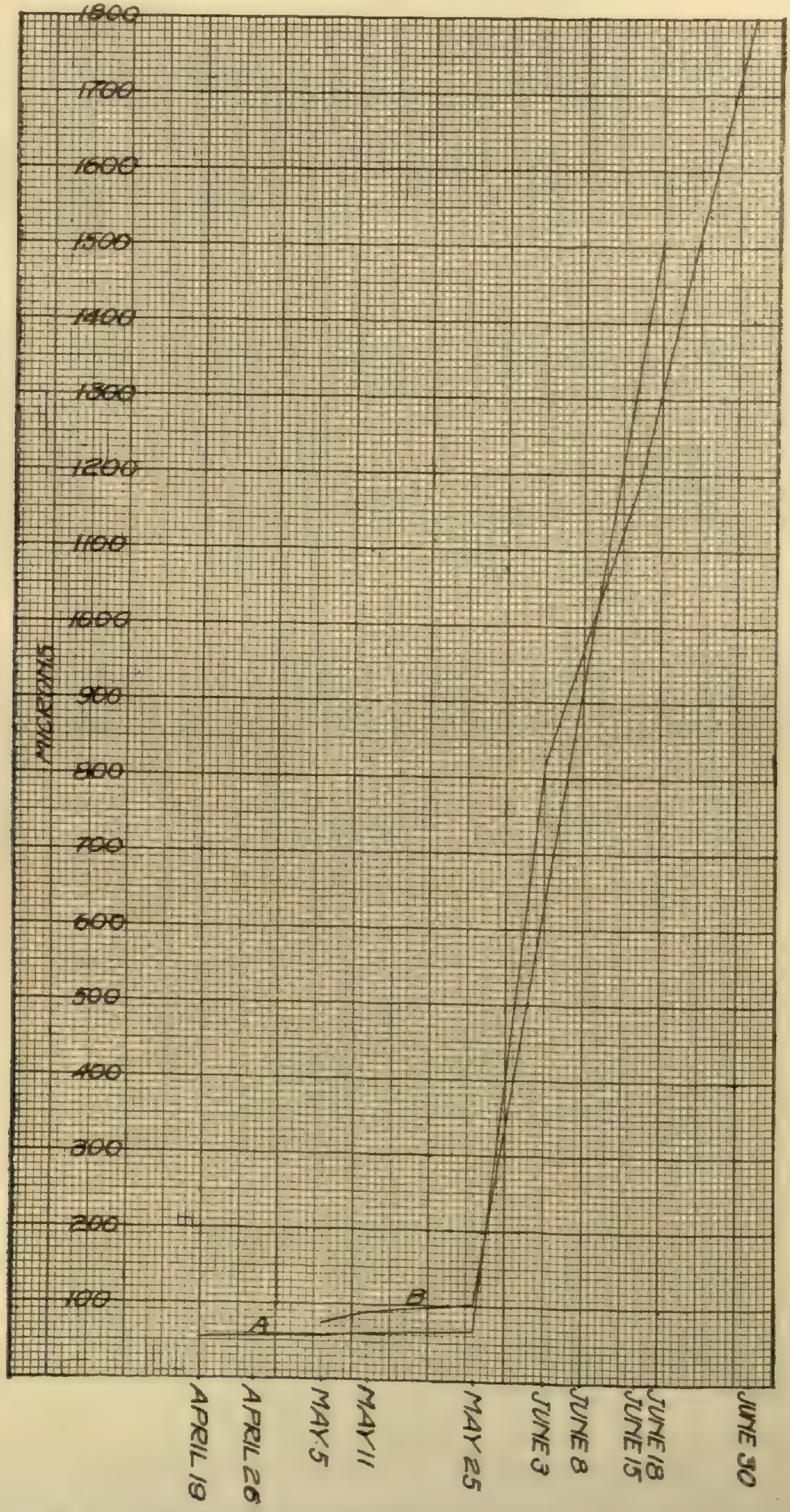

DIAGRAM II. *A*, diameter increase in trees *A* and *C*; *B*, diameter increase in trees *C* and *D*.

was removed. The removal, as before, was made from the south side of the tree. The branches were numbered according to their position on the tree, the topmost branch being No. 1, and the basal branch No. 7. From the individual branches there was removed from each season's growth a cutting; from the topmost branch two such cuttings were removed and from the basal branch

TABLE VIII

NUMBER OF ROWS OF XYLEM CELLS AND DIAMETER INCREASE OF XYLEM TISSUE IN THE CUTTING FROM LATERAL BRANCHES OF TREE *E*

No. of branch	Region of cutting on lateral branch	No. of rows of new xylem cells	Diameter increase of xylem
1	Below 1st whorl	0	0
1	Below 2d whorl	0	0
2	Below 1st whorl	0	0
2	Below 2d whorl	0	0
2	Below 3d whorl	0	0
3	Below 1st whorl	2	37 μ
3	Below 2d whorl	2	37 μ
3	Below 3d whorl	0	0
3	Below 4th whorl	0	0
4	Below 1st whorl	2	37 μ
4	Below 2d whorl	1	18 μ
4	Below 3d whorl	2	37 μ
4	Below 4th whorl	0	0
5	Below 1st whorl	2	29.6 μ
5	Below 2d whorl	1	18 μ
5	Below 3d whorl	0	0
5	Below 4th whorl	2	37 μ
5	Below 5th whorl	0	0
5	Below 6th whorl	0	0
6	Below 1st whorl	2	37 μ
6	Below 2d whorl	0	0
6	Below 3d whorl	0	0
6	Below 4th whorl	1	18 μ
6	Below 5th whorl	2	37 μ
6	Below 6th whorl	0	0
6	Below 7th whorl	2	18 μ
7	Below 1st whorl	0	0
7	Below 2d whorl	0	0
7	Below 3d whorl	1	18 μ
7	Below 4th whorl	0	0
7	Below 5th whorl	1	18 μ
7	Below 6th whorl	0	0
7	Below 7th whorl	0	0
7	Below 8th whorl	0	0

seven cuttings. These cuttings were fixed, sectioned, and prepared as before. In the following table the figures given refer only to the number of cells in the new xylem layer and to the diameter of that tissue. The diameter increase over the entire tree is represented in DIAGRAM III.

In order to show more clearly the results obtained and to aid in the interpretation the following two tables have been compiled from the preceding. In the TABLE IX are presented for each of the branches the average number of rows of xylem cells and the average diameter increase of the xylem tissue for the entire lateral branch. The averages are obtained from the figures for each individual cutting.

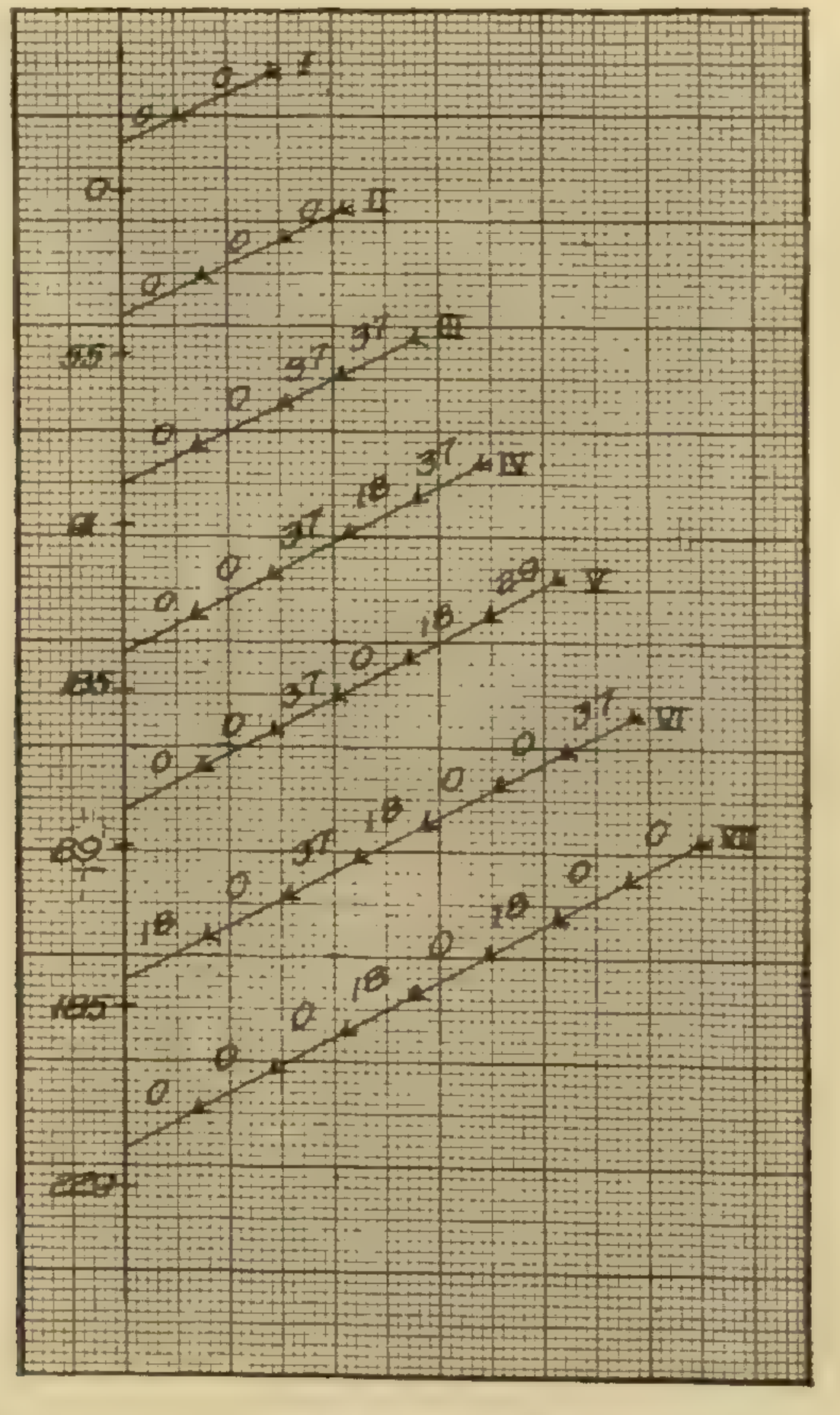

DIAGRAM III. Diameter increase of xylem in various parts of tree *E* on May 2

TABLE IX

AVERAGE DIAMETER INCREASE OF XYLEM IN LATERAL BRANCHES

Branch	Average no. of rows of new xylem cells	Average diameter increase of xylem
I	0	0 μ
II	0	0 μ
III	1	18 μ
IV	1.25	23 μ
V	0.83	14.1 μ
VI	1	15.7 μ
VII	0.25	4.5 μ

From the above table it is evident that the least growth occurred in the top and basal branches and the greatest growth

in the middle branches. This increase corresponds with the results secured previously on the diameter increase in the trunk, in which it was found that the growth first began in the middle region.

In regard to the second question as to the region of the branch in which growth first occurs, TABLE X is suggestive. The figures of the following table are the averages of the seven apical cuttings, the seven basal cuttings and the average diameter of xylem in the middle regions of the seven branches.

TABLE X

AVERAGE DIAMETER INCREASE OF XYLEM AT APEX, MIDDLE, AND BASE OF ALL LATERAL BRANCHES

Region of cutting	Diameter increase of xylem
Apical	20.8μ
Middle	7.5μ
Basal	2.5μ

From previous results it was expected that the growth would first occur in the middle of the branch, but the evidence indicates that the development of xylem in the lateral branches begins at the apex and then continues towards the base. The opening of the buds, however, does not follow the same order. On April 26, 1911, the lateral branches of a tree in the nursery row were examined and it was found that buds on the one and two years old wood had not yet opened, on the third year wood the leaves were just protruding while on the older wood the buds were fully opened.

In regard to the third question, "Does diameter increase in the twigs and branches precede that in the trunk?" the following observations were made. From the same tree from which the cuttings from the lateral branches were removed and on the same day,—namely, May 22, cuttings were removed from the apex to the base of the trunk. Seven such cuttings were removed from the south side of the tree, one cutting just below each whorl of branches. From a study of slides prepared from the material the following figures have been obtained. (See TABLE XI.) There are also included in TABLE XI figures derived from cuttings made on June 6.

A comparison of the figures for May 22 with the figures for growth in the lateral branches (see DIAGRAM III) reveals the fact

TABLE XI

NUMBER OF ROWS OF XYLEM CELLS AND DIAMETER INCREASE OF XYLEM IN TREE *E*

Region of cutting	No. May 22	Diameter increase of xylem May 22	No. June 6	Diameter increase of xylem June 6
Below 1st whorl . . .	0	0	——	——
Below 2d whorl . . .	3	55.5 μ	5	111 μ
Below 3d whorl . . .	5	91 μ	7	139.5 μ
Below 4th whorl . . .	7	185 μ	——	——
Below 5th whorl . . .	4	88.8 μ	9	259 μ
Below 6th whorl . . .	7	185 μ	17	444 μ
Below 7th whorl . . .	9	229.4 μ	20	481 μ
Average	5.8	139 μ	9.8	286 μ

that except for the apical part of the trunk the growth there has been much greater than in the branches. The average diameter increase of xylem in all the branches was by May 22 only 10.7 μ, and the average number of cells in the new xylem layer only 0.62. The greatest diameter increase in the branches was only 37 μ, while the average for the trunk was 5.8 cells with a diameter of 139 μ. If reference is made to TABLE VIII it will be seen that no growth occurred in branch No. 2 while in the trunk at this region the increase was 55.5 μ. The average diameter of xylem in branch No. 7 was only 4–5 μ, while in the region of the trunk from which the branch was secured the diameter increase amounted to 229 μ. It is very evident, therefore, that in a larch of this age under isolated conditions growth does not begin first in the twigs and then extend to the trunk, but rather it begins first in the trunk.

The figures in TABLE XI give no strong indication of the region in which growth first began. The diameter increase was greatest just below the 4th, 6th, and 7th whorls of branches. No increase was manifest near the apex.

TABLE XII

Region of cutting in trunk	No. of rows of xylem cells	Dia. increase of xylem
Below 1st whorl	Cutting lost	——
Below 5th whorl	4	111 μ
Below 7th whorl	9	222 μ
Below 9th whorl	5	129 μ

In order further to check the work of 1909 a few cuttings were made from another tree in the nursery row on May 22. This tree

was now approximately 15 years of age. Cuttings were removed from the south side of the trunk below the 1st, 5th, 7th, and 9th whorls of branches. The results from the measurement of the xylem are found in TABLE XII.

While no conclusions can be drawn respecting the inception of growth the indications again point to the middle region. The figures are of interest mainly because of the fact that growth of xylem has occurred before May 25, which was the date of xylem development in 1909.

FACTORS INFLUENCING DATE OF XYLEM FORMATION

Temperature, moisture, and insolation are important factors in all growth phenomena. In 1909 and 1911 the opening of buds of larch began April 19. In 1909 the xylem formation began on May 25, while in 1911 the xylem formation began about May 20.* The temperature, moisture, and sunshine figures for the intervals between the bud opening and wood formation are found in the following table. The mean temperature for the day is considered as the number of heat units for that day, and the total heat units† is considered as the sum of these mean temperatures.

Period	Total heat units	Hours of sunshine	Precipitation
April 19—May 25, 1909...	1,810	234.5	2.89
April 19—May 20, 1911...	1,769	257.	2.00

The number of heat units then during the interval before wood formation in 1911 was almost as great as that during the longer period of 1909, while the amount of sunshine was greater during the 1911 period. The amount of precipitation at this time of the year was not important as sufficient water was available both seasons. In 1911, however, the mean temperature for the three days preceding wood formation ranged from 76° F.–78° F. and for the three days preceding this period the range of the mean temperatures was 62° F.–69° F. During 1909 the nine days preceding wood formation ranged in mean temperature from 50° F.–54° F. except one day which had a mean temperature of 58. The three

* The exact date of xylem formation was not determined. The observation on May 22 showed a diameter increase of 6 cells.

† No daily mean temperature was below 34° F.

days preceding wood formation in 1909 had 39.4 hours of sunshine; the same period in 1911 had 26.2 hours of sunshine. It is very probable therefore that during 1911 the relatively higher temperature for the six days preceding wood formation was important in hastening the inception of xylem formation.

SUMMARY

RESULTS OF 1909. (1) *Cambium and phloem development.*—The cambium in the trunk during the resting condition consists of six rows of cells 34 μ diameter. On April 19 the first material collected exhibited an increase in diameter of the cambium tissue. The cambium cells were all enlarged while the outer cells were in the process of transformation, changing from a rectangular to square shape as viewed in cross section. In the middle regions of the trunk on April 19 an increase in phloem cells was evident. The increase of cambium and phloem was gradual over the entire trunk in tree *A* up to May 25, the greatest increase being maintained in the middle region. Similar conditions were found in tree *B*, though here the increase of new phloem cells was more marked. The greatest growth of phloem occurred immediately after May 25 and was coincident with the greatest development of xylem.

(2) *Xylem development.*—In tree *A* no xylem was formed before May 25. In tree *B* a few xylem cells were formed by May 25 in the middle regions of the trunk. Growth of xylem was almost simultaneous, however, in all parts of the trunk. The greatest growth occurred immediately after May 25 and in tree *C* the xylem was nearing completion by July 6.

RESULTS OF 1911.—(1) Growth in diameter in the lateral branches begins first in the middle branches and is followed by that in the basal and apical branches.

(2) In the individual branches growth begins first at the apex and then descends towards the base.

(3) Diameter increase of the trunk precedes that in the branches and twigs.

(4) Temperature and insolation conditions in 1911 induced wood formation five days earlier than in 1909.

(5) No direct evidence was secured in 1911 concerning the

region in the trunk of first cambial activity. Indications pointed again to the middle and basal regions.

DISCUSSION OF RESULTS

In a number of anatomical text books it is stated that the xylem development precedes that of the phloem. This idea is conveyed rather ambiguously by Stevens.* In the American larch the development of phloem certainly precedes that of xylem and its most rapid development is coincident with that of the xylem. Brown's† figures indicate that in *Pinus rigida* a similar condition prevails.

The results obtained by the writer do not agree with those of Th. Hartig‡ with 30-year old European larch, wherein diameter increase near the base of the trunk was two to four weeks later than that in the twigs and branches. The factors which may operate to cause this difference are considered subsequently. My results agree with those of Brown§ who finds that in *Pinus rigida* the first diameter increase of xylem begins a few meters below the apex. The work of Brown was done during the same period as that of the writer and on trees in a plot adjacent to those used in this investigation.

Respecting the date of diameter increase Buckhout states that in European larch it is coincident with leaf formation. It is very probable that the diameter increase at this time is due mainly to a swelling of the tissues. In my investigations the development of xylem began a month later than the beginning of leaf formation. From observations made during the past two years with a considerable number of trees and from the results of other investigators it seems probable that in general growth in diameter does not begin until the leaves have been fully developed and have been sufficiently active in food making to supply the requirements of rapid cell formation. The reserve foods stored up in the fall are probably largely utilized in leaf and also in blossom formation, when the latter precede the formation of leaves.

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* Stevens, W. C. Plant anatomy, 2nd Ed., p. 170. 1910.

† Brown, H. P. Growth studies in forest trees, I. *Pinus rigida* Mill. Bot. Gaz. 54: 386–402. 1912.

‡ Hartig, T., loc. cit.

§ Brown, H. P., loc. cit.

What factors operate to cause growth inception in a particular part of a tree? Robt. Hartig* believed that temperature was the most important factor, consequently insolation, temperature of the air and of the soil moisture, and thickness of the bark are the essential factors which determine the region of first diameter increase. No doubt these factors are important, as considerable evidence indicates that in old trees diameter increase is delayed at the base of trunk where insolation is poor and the bark is thick. In young trees, however, these are not the only factors. In the larch trees of 13 years of age the diameter increase did not begin first in those regions with the thinnest bark and best insolation. The thickness of the bark at the apex, middle and base of the tree *A* was respectively 596 μ, 1,937 μ, and 3,278 μ. So also in the isolated tree *E* the inception of diameter increase did not occur in the parts of the tree best insolated and with the thinnest bark, but rather in the thicker barked and more poorly insolated parts of the tree, namely the middle and basal regions of the trunk. In the individual branches, however, growth in diameter began in the regions of thinnest bark and of best insolation.

Whitten† has shown that the color of the bark may be important in the time of growth inception of buds. The color of the bark may be a factor in determining the region of diameter increase in young trees of larch. The color of the bark of the apical part of the trunk in spring is yellowish to greenish, becoming darker towards the base. The darker color, because of its capacity for heat absorption, may counteract the insulating effect of the thick bark, consequently the diameter increase begins in the basal and middle regions. The growth begins first in the middle regions because the bark here is of the same color as that of the basal regions and is only about half as thick. The fact that in the branches and twigs of larch the opening of buds on the apical regions is retarded is suggestive of the influence of the color of the bark. The bark of the apical regions being of lighter color less heat is absorbed, its temperature therefore is lower and the development of the buds is slower. This is in agreement with the

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* Hartig, R., loc. cit.

† Whitten, J. C. Winter protection of the peach. Missouri Agr. Exp. Sta. Bull. 38: 140–164. 1897.

results obtained by Whitten* on the date of blossoming of green- and purple-twigged peach trees.

The temperature of the soil moisture and of the air, and the thickness and color of the bark are not the only factors operative in inducing diameter increase. Certainly as regards all of the above factors the branches are all more favored than the trunk of the tree, yet in the isolated tree *E* the diameter increase began first in the trunk. Food supply may be a factor in stimulating the cambium of the trunk to diameter increase, before there is development in the branches. It is not possible to state the influence of food supply. Controlled experimental work with this as well as with the other factors is necessary to give an idea of the influence of each in stimulating the cambium to activity.

In conclusion it should be stated that considerably more work is necessary in order to establish the region of the tree in which cambium activity first begins. No doubt different conditions will be found for trees of the same species of different ages, and for trees of different species and genera. Investigations of this character are important because only by such studies can the factors be determined which stimulate cambium activity. It is essential also to determine the period and extent of phloem and xylem formation in trees and the duration of cambium activity. Much more work remains to be done along this line. Such work is of especial importance in fruit culture and in a subsequent paper the results of such an investigation will be presented.

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Explanation of figures

FIG. 1. Cutting no. 6 made from trunk on November 13, showing cambium tissue *a* to *a*, consisting of six rows of cells; ×475.

FIG. 2. Shows extent of cambium in basal cutting, No. 10, made on May 5. Compare with Fig. 2; ×475.

FIG. 3. Cutting no. 6 taken from trunk of tree *A* on May 5. Cambium *a* to *a*. Note the increased diameter and cell differentiation; ×475.

FIG. 4. Cutting no. 5 made on May 25 from tree *A*. Xylem formation not yet begun; ×33.

FIG. 5. Cutting no. 4 from tree *C* made on June 3; ×33.

FIG. 6. Cutting no. 7 from tree *C* made on June 30; ×33.

FIG. 7. Cutting no. 8 from tree *C* made on July 8. Differentiation of summer wood is beginning; ×33.

* Whitten, J. C., loc. cit.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1910–1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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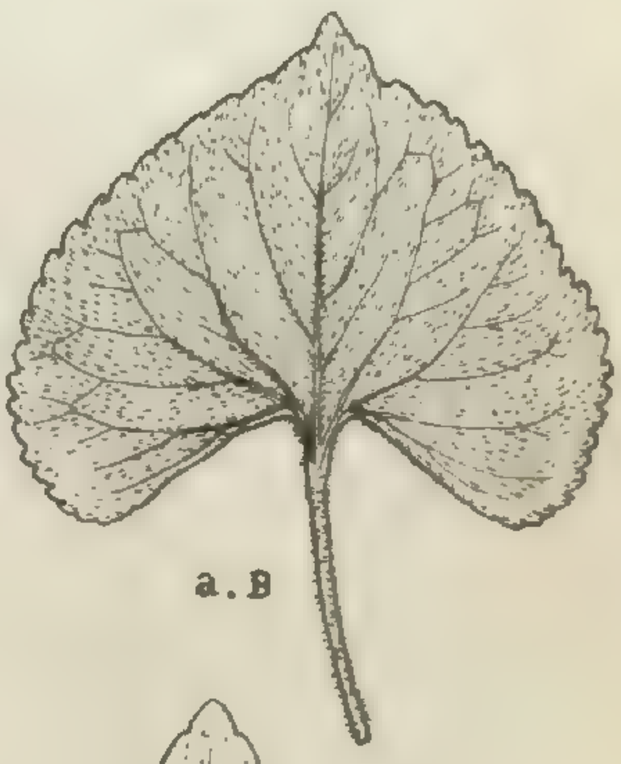
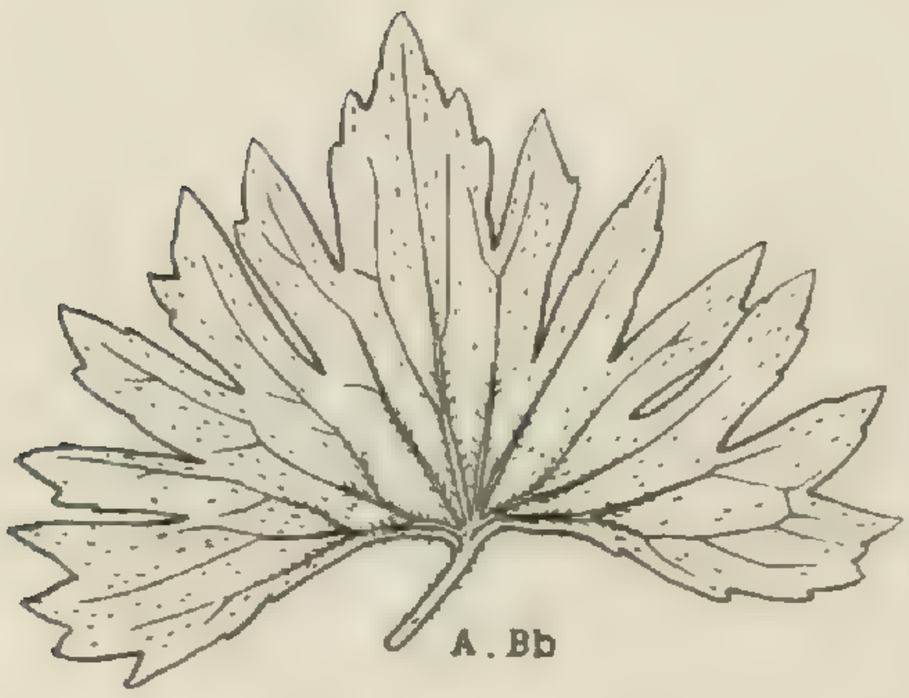
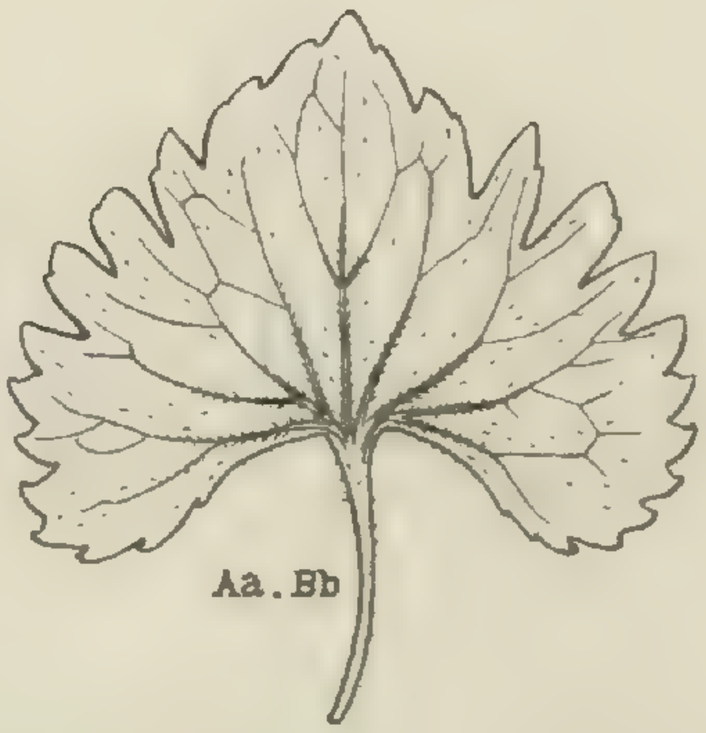
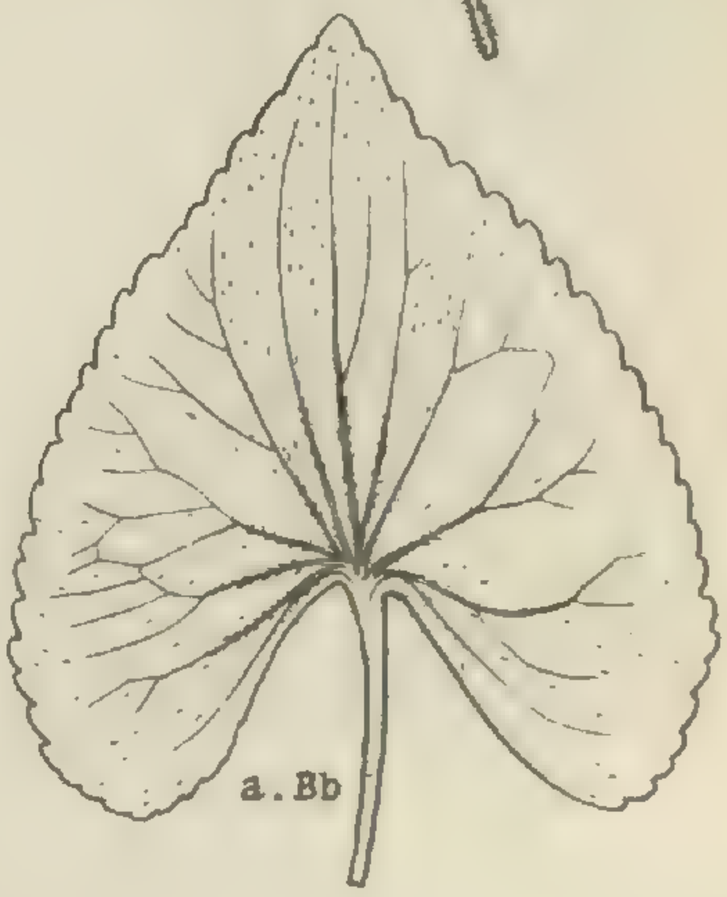
VIOLA PAPILIONACEA ×PEDATIFIDA AND TWO OF ITS SEGREGATE OFFSPRING

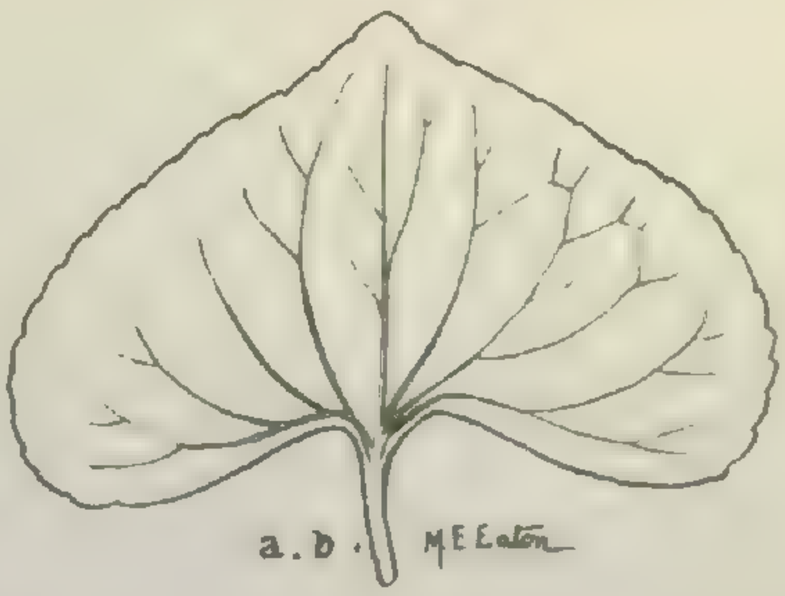
VIOLA PEDATIFIDA × SAGITTATA AND LEAVES OF ITS PARENTS AND OF NINE OFFSPRING











LEAVES OF VIOLA PEDATIFIDA × SORORIA, OF ITS PARENTS, AND OF NINE OFFSPRING

FIG. 1

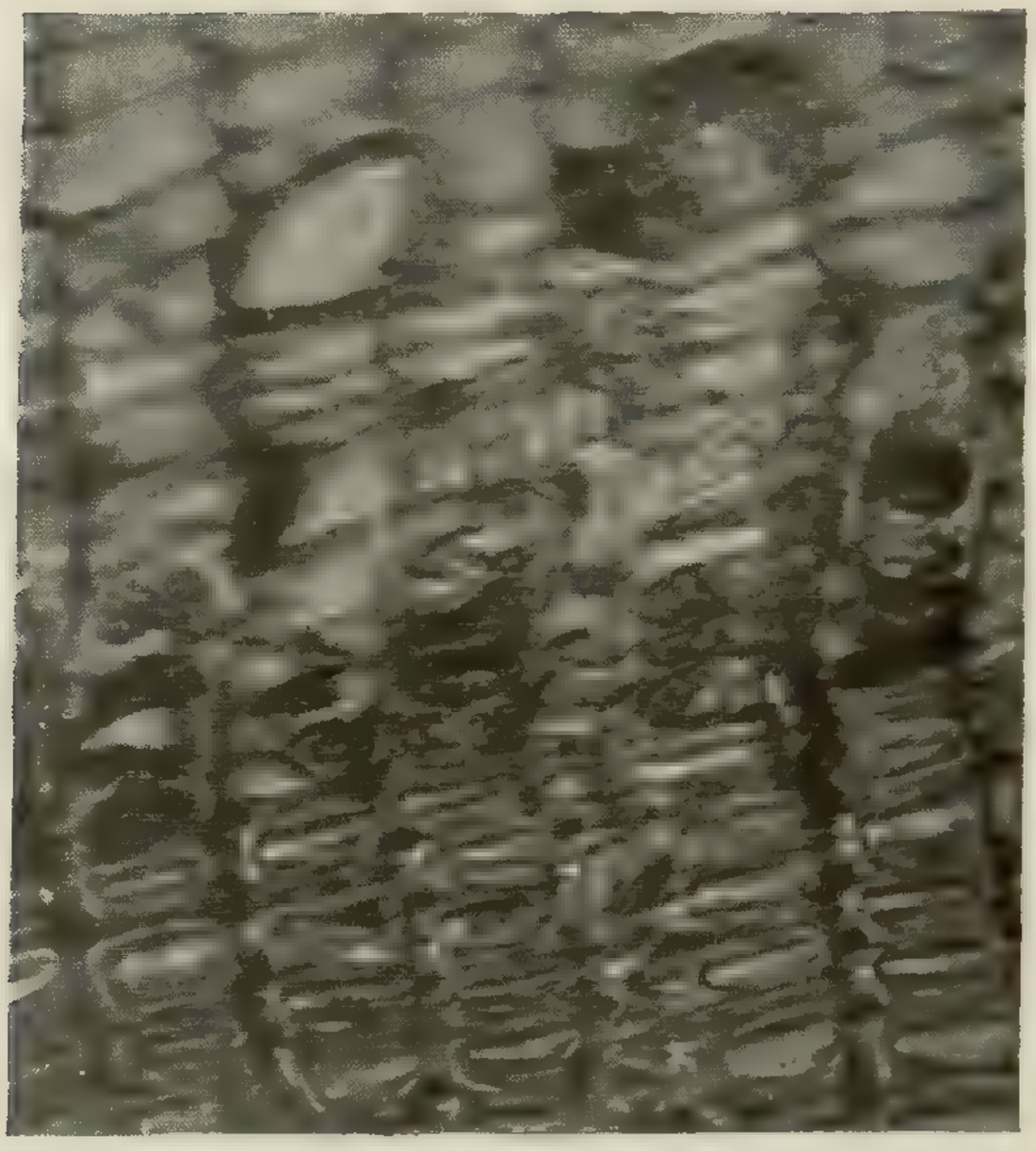


FIG. 2

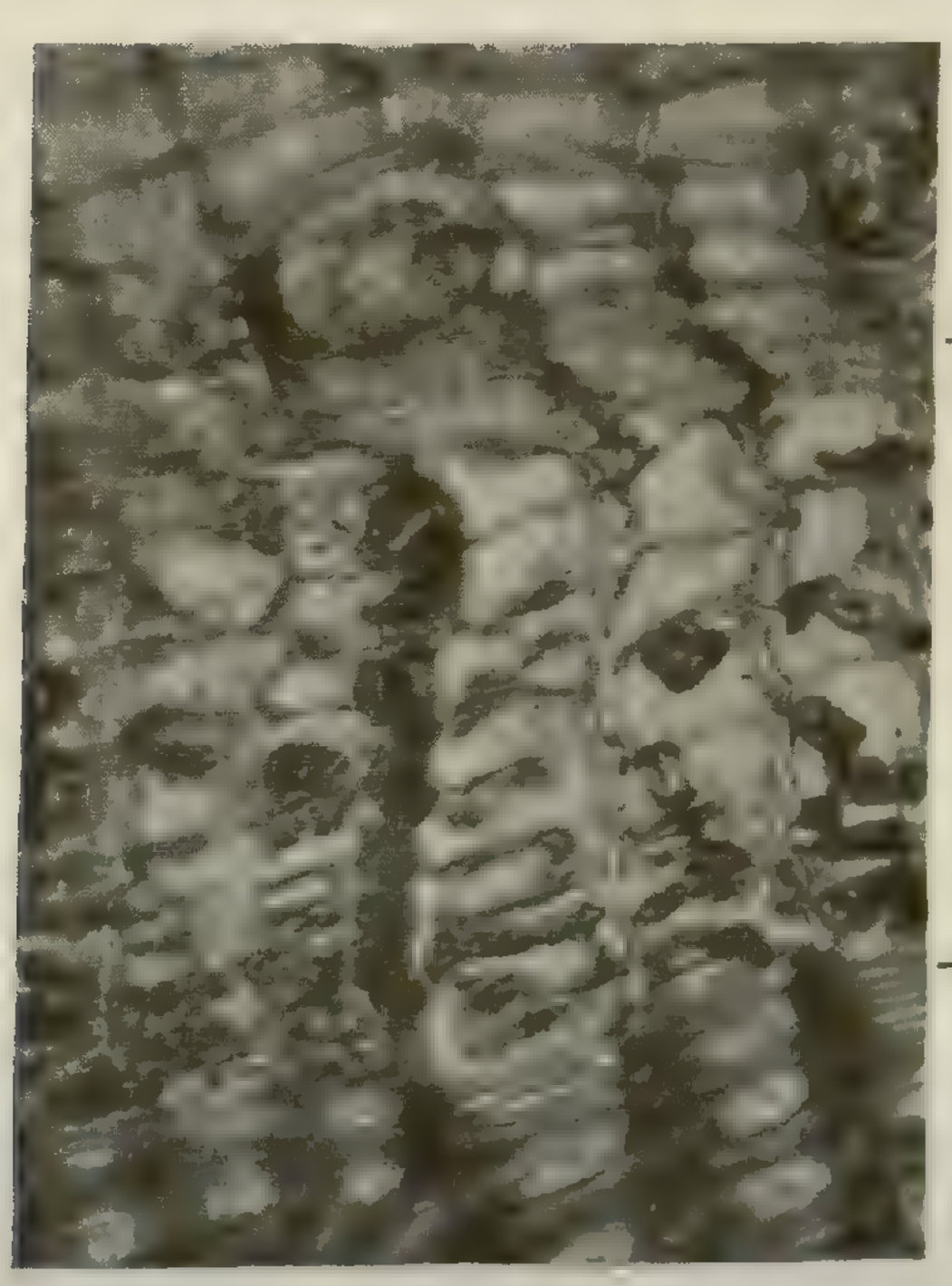


FIG. 3

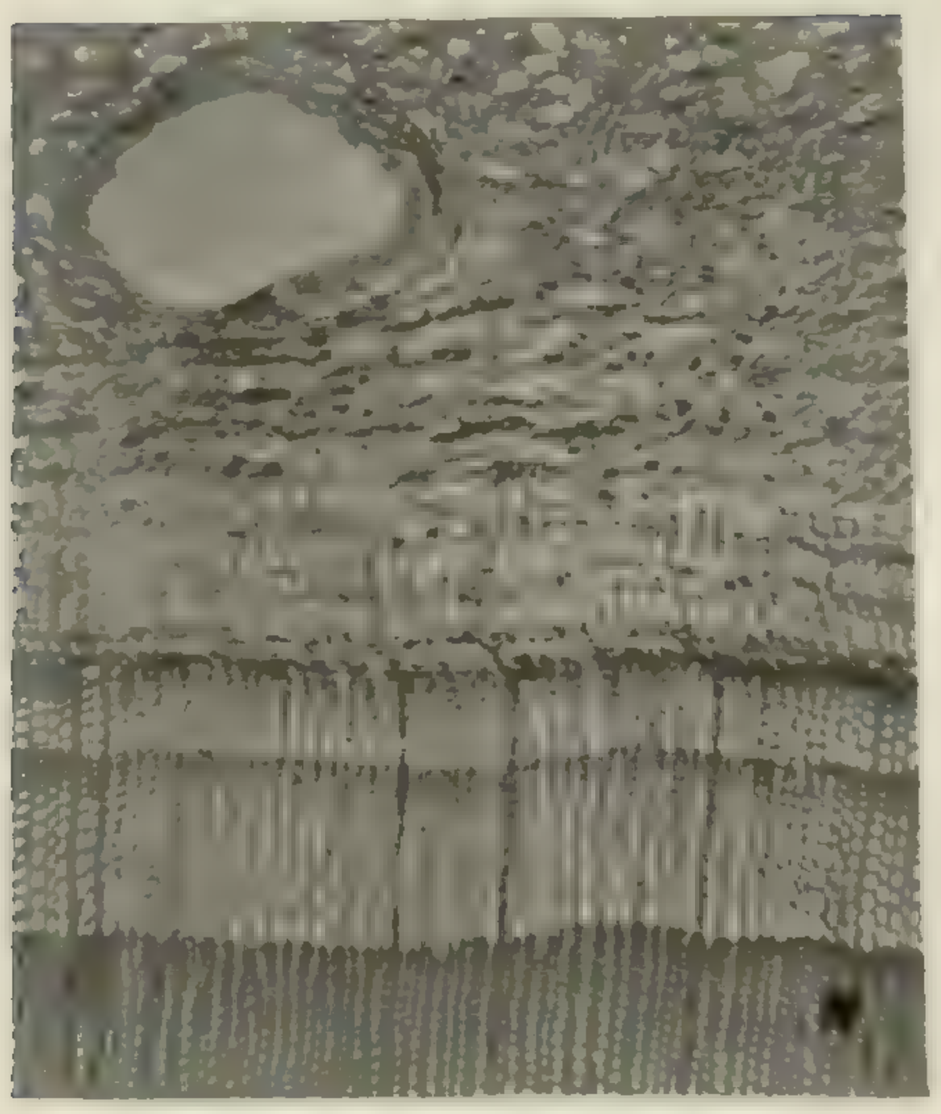


FIG. 4

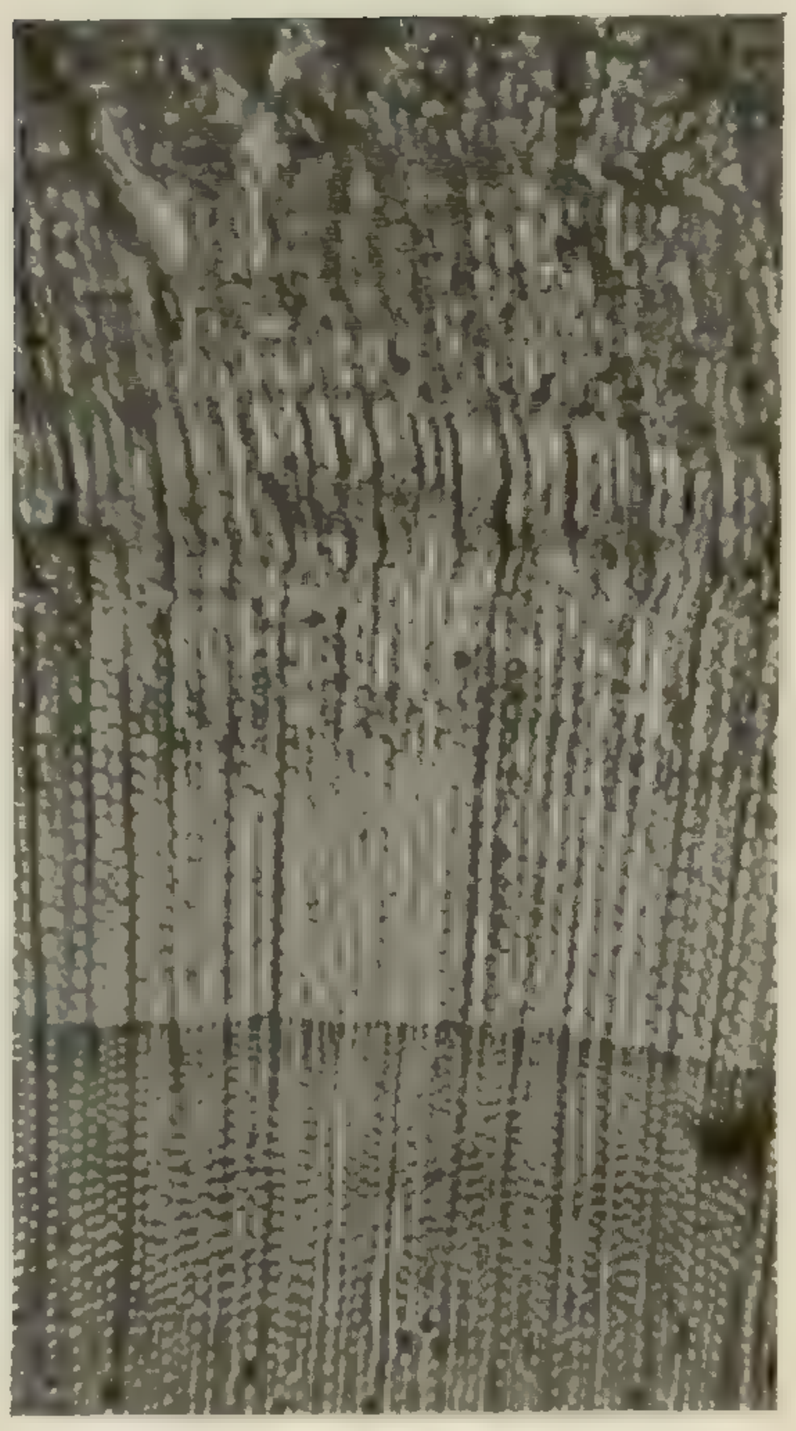


FIG. 5

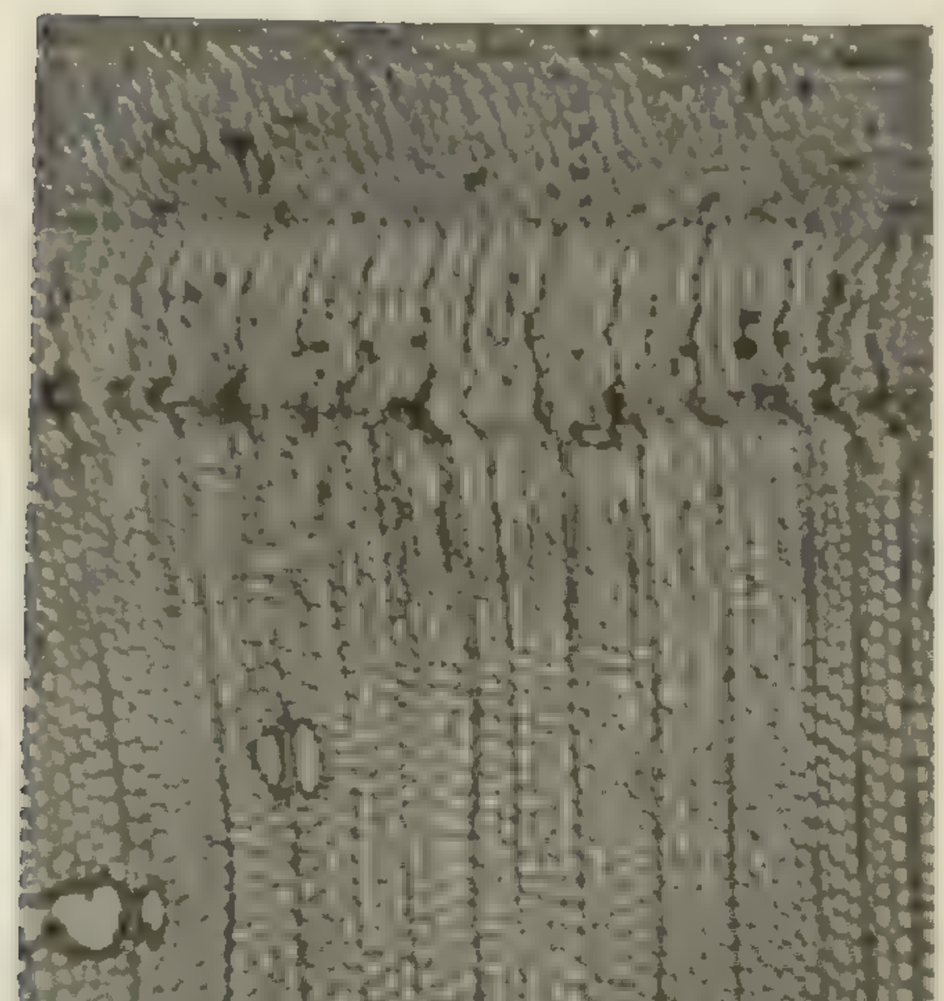


FIG. 7

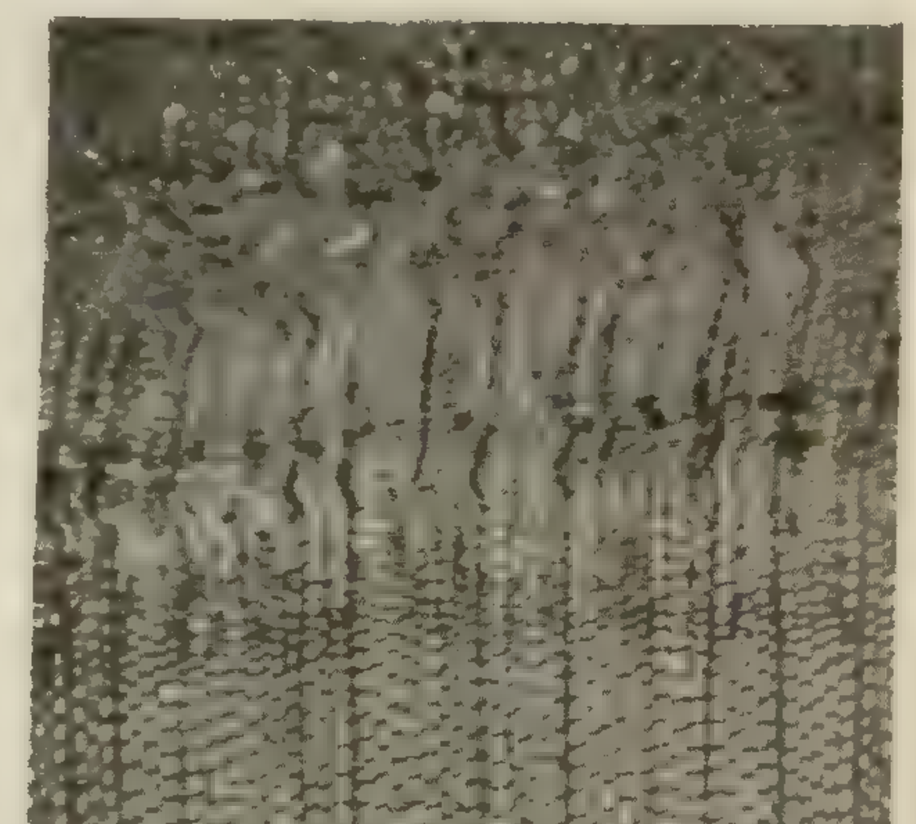


FIG. 6

Vol. 40 No. 7

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1913

Studies on the West Indian Vernonieae, with one new species from Mexico

HENRY ALLAN GLEASON

Seven years ago, in the Revision of the North American Vernonieae,* forty-three species and one variety of *Vernonia* were recognized from the West Indies, together with several species of other genera. Since that time, the New York Botanical Garden has been actively engaged in the systematic exploration of these islands, especially Cuba, and has accumulated much valuable material. Director N. L. Britton has recently extended to me the facilities of the Garden, and has given me the opportunity to examine the new material in this tribe of Carduaceae. The results of this study are herewith presented.

Of the forty-four species and varieties recognized in the revision, three have been found untenable and are reduced to synonymy: *V. sublanata* Gleason, *V. Thomae* Benth., and *V. Sintenisii* (Urban) Gleason. The variety has been raised to specific rank. Four old species, not recognized in the revision, are shown by the recent collections to be distinct, and are admitted as species: *V. acuminata* Lessing, *V. Ottonis* Sch.-Bip., *V. Wrightii* Sch.-Bip., and *V. fruticosa* (L.) Sw. For the identification of the latter, we are indebted to Dr. Urban, who has also described a new species, *V. Tuerckheimii*. The collections at the Garden, supplemented by some material loaned by the Gray Herbarium and the Missouri Botanical Garden, are also found to contain seventeen

* Bull. N. Y. Bot. Gard. 4: 144–243. 1906.

[The BULLETIN for May 1913 (40: 193–248. *pls. 9–14*) was issued May 20; the BULLETIN for June 1913 (40: 249–304. *pls. 15–19*) was issued June 18.]

new species, which are here described. The total number of species of *Vernonia* recognized from the West Indies at the present time is therefore sixty-three. In addition, an Asiatic species escaped or adventive in Guadeloupe has been found to differ from *Vernonia* in particulars important enough to warrant its segregation, and a new species of the related genus *Eremosis* has been described from Mexico.

CYANTHILLIUM Blume, Bijdr. Flora Nederl. Indie 889. 1826

Isonema Cass. Bull. Soc. Philom. **1817**: 152. 1817. Not *Isonema* R. Br., 1809.

Cyanthyllium Blume, Flora Javae 1: vi. 1828.

Cyanopis Blume, Flora Javae 1: vi. 1828; DC. Prodr. 5: 69. 1836.

Cyanopsis Endl. Ench. 232. 1841. Not *Cyanopsis* Cass. Bull. Soc. Philom. **1817**: 200. 1817.

Claotrachelus Zoll. Nat. en Geneesk. Arch. Neêrl. Indie **2**: 565. 1845, *fide* Hoffman, in Engl. & Prantl, Nat. Pfl.-Fam.

The genus differs from *Vernonia* in its very fragile, uniseriate pappus, and its 4–5-angled achenes.

Cyanthillium chinense (Lam.) comb. nov.

Eupatoria conyzoides foliis glabris summo caule ramosior, lamii folio flore purpureo Pluk. Phytographia *pl. 177. f. 2.* 1691.

Conyza chinensis Lam. Encyc. 2: 83. 1786.

Conyza patula Ait. Hort. Kew. 3: 184. 1789.

Isonema ovata Cass. Dict. Sc. Nat. 24: 25. 1822.

Conyza odorata Willd. in Spreng. Syst. 3: 511. 1826.

Cyanthillium villosum Blume, Bijdr. Flora Nederl. Indie 889. 1826.

Cyanthillium pubescens Blume, Bijdr. Flora Nederl. Indie 890. 1826.

Centratherum chinense Less. Linnaea **4**: 320. 1829.

Vernonia chinensis Less. Linnaea **6**: 105, 674. 1831.

Cyanopis pubescens DC. Prodr. 5: 69. 1836.

Cyanopis villosa DC. Prodr. 5: 69. 1836.

Claotrachelus rupestris Zoll. Nat. en Geneesk. Arch. Neêrl. Indie **2**: 565. 1845.

As long ago as 1829 Lessing mentioned a specimen of this species from the "insulis Caribaeis" in Willdenow's herbarium. The herbarium of the New York Botanical Garden now contains a specimen from Guadeloupe, *Duss 4032*, where it occurs in a single locality. It is therefore admitted as a member of the North American Flora.

SPECIES-GROUP ARBORESCENTES

Vernonia icosantha DC. Occurs also in Guadeloupe Island, *Duss 2812*.

Vernonia arborescens (L.) Sw. This species, typically of Jamaica, occurs also in Grand Cayman, *Hitchcock*, in the herbarium of the Missouri Botanical Garden.

Vernonia amaranthina sp. nov.

Apparently herbaceous and freely branched, height not reported; stem and branches straight, striate, closely and softly pubescent or tomentulose, the branches ascending; leaves spreading, firm, rather dull green, ovate-lanceolate to narrowly oblong-elliptical, the principal ones 7–9 cm. long by 2–3 cm. wide, acute or short-acuminate, entire or somewhat irregular at the margin, but not serrate, narrowed to an acute base, minutely papillose-pubescent and scabrellate to the touch above, pubescent, especially along the veins, and minutely glandular beneath, veins conspicuous, elevated beneath, the lateral ones strongly ascending; petioles definite, 5–10 mm. long, pubescent or tomentulose; inflorescence freely branched and spreading; cymes short, naked below and bearing 2–5 heads aggregated near the tip, or separated by internodes less than 1 cm. long; rameal leaves resembling the cauline but smaller, those subtending the cymes narrowly oblanceolate, 1–2 cm. long, those subtending the heads linear to narrowly oblanceolate, shorter than or barely equaling the involucre; heads 21–29-flowered, sessile; corolla purple; involucre campanulate, about 5 mm. high, its scales purplish, thinly pubescent, irregularly imbricated, the outer triangular to ovate, sharply acute and somewhat cuspidate, the inner oblong, rounded to a mucronulate tip; achenes densely hirsute, 1.5 mm. long; pappus white, 4 mm. long, the outer series conspicuous.

Type, *E. G. Britton 2897*, from "Greenland," Jamaica, March 13, 1908, in the Herbarium of the New York Botanical Garden. *Britton & Hollick 2133*, from Green Island, Jamaica, is also

referred here. The latter is a virgate plant 2 meters high, and the inflorescence is consequently small and composed of relatively few heads. It differs in no essential way from the type.

V. amaranthina is distinguished from *V. arborescens*, its nearest relative, by the rounded and mucronulate inner scales of the involucre and its short contracted cymes, contrasting with the acute or acuminate inner scales and elongated cymes of *V. arborescens*.

SPECIES-GROUP ARARIPENSES

A. Leaves of a linear type, 1–5 mm. wide, one-nerved, more or less revolute.

1. Leaves linear to narrowly lanceolate, 3–5 mm. wide; inner scales broadest above the base, purpiish or brown; middle and outer scales glabrate; pappus tawny or pale brown. *Vernonia araripensis.*

2. Leaves 1–4 mm. wide, linear; inner scales broadest near the base; all scales densely strigose, pale-green; pappus white or very pale yellowish-brown.

a. Leaves 3–8 cm. long, densely papillose-pubescent above; inflorescence divaricately branched; heads 18–21-flowered. *Vernonia stenophylla.*

b. Leaves 1–3 cm. long, strigose-hispid above; inflorescence slender, virgate; heads 11-flowered. *Vernonia corallophila.*

B. Leaves 4–20 mm. wide, narrowly oblong to oblong-obovate, mucronate; inner scales broadest above the base; all scales strigose-pubescent; pappus white or nearly so.

1. Leaves narrowly oblong with parallel sides, without conspicuous lateral veins beneath. *Vernonia angustata.*

2. Leaves broadest near or above the middle, veiny. *Vernonia gnaphaliifolia.*

The status of the first three species in the key above is still open to question and may require future adjustment. Gardner's type locality for *V. araripensis* was in Brazil, and it is scarcely probable that the same species occurs in the Antilles, especially as far as Cuba or Santo Domingo. Authentic specimens of Lessing's *V. stenophylla* have not been seen, and the plants referred to his name differ in some slight features from the original description. Both species are accepted solely on the authority of certain European students of the genus.

Vernonia corallophila sp. nov.

Stem erect, herbaceous, 4 dm. high, virgate, finely striate, strigose-pubescent; leaves sessile, narrowly linear, rigid, revolute, one-nerved, 1–3 cm. long, strigose-hispid and punctate above, densely strigose-pubescent beneath; inflorescence cylindrical or sparingly branched; heads 11-flowered, in the axils of the upper leaves or rarely 2 or 3 together on a short ascending lateral cyme; bracteal leaves resembling the cauline, but reduced in size and the upper barely exceeding the heads; involucre turbinate, 5–6 mm. high, its scales all straight, erect, very loosely imbricated, strigose-pubescent, the outer subulate, the inner narrowly oblong, long-acuminate; achenes pubescent, 2 mm. long; pappus nearly white, the inner series 4–5 mm. long.

Type, *Britton 1939*, from a coral limestone beach at the United States Naval Station, Guantanamo Bay, Oriente, Cuba, March 17–30, 1909, deposited in the Herbarium of the New York Botanical Garden.

The species is readily distinguished by its slender virgate inflorescence and small leaves from *V. stenophylla* with its long leaves and divaricate inflorescence.

Vernonia angustata sp. nov.

Vernonia sublanata angustata Gleason, Bull. N. Y. Bot. Gard. 4: 177. 1906.

Herbaceous, height not stated; stems slender, puberulent or thinly pubescent, sparingly branched above; leaves thin, flat, spreading, narrowly oblong with parallel sides, 3–5 cm. long, 4–8 mm. wide, obtuse or rounded, mucronate, entire, acute at the base, thinly pubescent above, closely gray-tomentose beneath, one-nerved; petioles 1–2 mm. long; cymes few, widely spreading or horizontal, simple or sparingly branched, bearing 2–7 heads each; internodes 1–2 cm. long, depressed or gently curved between the heads; bracteal leaves like the cauline, but gradually reduced in size, and the upper only 1 cm. long; heads sessile, distinctly secund, about 18-flowered; involucre broadly campanulate, 6–7 mm. high, its scales loosely and irregularly imbricated, strigose-pubescent, acuminate or sharply acute, the outer lanceolate, the inner narrowly oblong; achenes pubescent, 2 mm. long; pappus white, the inner series 6 mm. long.

VERNONIA GNAPHALIIFOLIA Rich. in Sagra, Hist. Fis. Pol. Nat. Cuba 11: 34. 1850

Vernonia sublanata Gleason, Bull. N. Y. Bot. Gard. 4: 177. 1906.

Dr. Urban has established the identity of these two species by the examination of authentic material, and they are accordingly united here. The species appears to be common and widely distributed in Cuba from the province of Havana eastward.

SPECIES-GROUP DIVARICATAE

The history of this group of Vernonieae begins with the publication of *V. divaricata* by Swartz in 1806. This was followed in 1831 by Lessing's *V. acuminata*, and no further addition was made to the group until 1906, when Gleason described *V. albicoma* and *V. expansa*. During the last half-century *V. divaricata* and *V. acuminata* have been usually considered identical. The whole group, so far as known, is confined to Jamaica, and the ample collection in the Herbarium of the New York Botanical Garden includes seven distinct species.

At the present time the chief difficulty lies in determining to which of these seven species the old names *divaricata* and *acuminata* belong. Certain characters given by the authors in their original descriptions serve to exclude one or another of the species, and by this process of exclusion it is possible to arrive finally at a reasonable conclusion. It may be safely affirmed that the two species described below are the only ones examined to which these names can consistently be given, without doing violence to some important feature of the original description.

VERNONIA DIVARICATA Sw. Fl. Ind. Occ. 3: 1319. 1806

A straggling shrub, 1–2 m. high; leaves spreading, thin, bright green, elliptical or elliptical-lanceolate, 4–7 cm. long, 1.5–2.5 cm. wide, acute or subacuminate, entire, narrowed to an acute base, minutely puberulent above, thinly pubescent and finely punctate with minute pellucid glands beneath, sessile or with petioles 1–5 mm. long; inflorescence of numerous, lax, loosely flowered, divaricate cymes, bearing each 5–15 secund heads, and frequently prolonged into a leafy shoot; bracteal leaves oblanceolate to narrowly oblong, barely exceeding the 11–13-flowered heads; involucre campanulate, about 4 mm. high; scales thinly strigose-

pubescent, the inner oblong, gradually narrowed to a rounded tip, the outer triangular-ovate, obtuse or acute.

The following specimens are referred here: JAMAICA: *Harris 8205*, altitude 500 m.; *Britton & Hollick 1996*, altitude 700 m.; *Britton 431, 679; Cockerell.*

VERNONIA ALBICOMA Gleason, Bull. N. Y. Bot. Gard. 4: 185. 1906

Stem woody, slender; leaves thin, bright green, elliptical or elliptical-lanceolate, 5–6 cm. long, 1.5–2.3 cm. wide, acuminate, subentire, tapering at the base, glabrate above, very finely pubescent or glabrous beneath; petioles 5–7 mm. long; upper leaves somewhat reduced; inflorescence of 1–3 curved spreading terminal cymes bearing each 5–10 sessile secund 18-flowered heads; bracteal leaves lance-oblong, the middle ones about equaling the involucre, which is broadly campanulate or hemispheric, 5 mm. high; scales erect, loosely and irregularly imbricated, nearly glabrous, the outer lanceolate, acuminate, the inner oblong, acute; pappus white.

Campbell 6152, from the foot of Long Mountain, Jamaica, altitude 115 m.

VERNONIA ACUMINATA Less. Linnaea 6: 663. 1831

Shrubby, height not stated; stem finely cinereous-puberulent; leaves thin, bright green, broadly ovate-lanceolate, 6–9 cm. long and half as wide, long-acuminate, entire, acute at the base, very sparsely and minutely puberulent on both sides, on petioles about 5 mm. long; inflorescence of numerous widely spreading freely branched cymes, the ultimate branches bearing 3–7 heads; rameal leaves lanceolate, 2–3 cm. long; bracts oblong-lanceolate to linear, those at the ends of the cymes only 6 mm. long; heads 18-flowered; involucre campanulate, about 5 mm. high, its scales all obtuse or the outer acute, pubescent, especially the outer series, the exposed portion of the inner series oblong.

Wight 20, from wooded hillsides, Port Antonio, Jamaica.

VERNONIA EXPANSA Gleason, Bull. N. Y. Bot. Gard. 4: 186. 1906

A straggling shrub 2.5–3 m. high, branching above; leaves numerous, rather crowded, thin, divaricate, ovate, 3–5 cm. long, 1.7–2.7 cm. wide, acute or subacuminate, entire, obtuse or broadly rounded at base, sparsely and finely pubescent, or nearly glabrous above; petioles 3 mm. long; upper and rameal leaves smaller, broadly elliptical, obtuse; inflorescence of several short cymes bearing each 3–6 heads; bracteal leaves equaling or much shorter

than the involucre; heads crowded, sessile, 11-flowered; involucre broadly campanulate, 4 mm. high; scales all appressed, closely imbricated, glabrous or nearly so, rounded at the tip, the outer broadly ovate, the exposed portion of the inner ovate.

JAMAICA: *Harris 8796*, near Troy, altitude 2,000 ft., *Britton & Hollick 1956*, woods, Bluefields Mountain, altitude 750 m.

Vernonia pluvialis sp. nov.

Apparently erect and branched only near the top, height 4 dm. or more; stem finely striate, glabrate, or thinly pubescent, especially above; leaves spreading, or usually ascending, firm and rigid, oblong-ovate to subrhomboid, broadest conspicuously above the middle, the principal ones 3–5 cm. long by 1.1–1.9 cm. wide, acute, entire and subrevolute, gradually narrowed to an obtuse base, minutely puberulent on both sides and glandular-punctate below; veins not prominent, sessile or on petioles 1–2 mm. long; inflorescence of several short few-headed cymes in the axils of the upper leaves, forming a compact leafy panicle; bracteal leaves barely exceeding the heads, ovate to ovate-lanceolate; heads crowded in clusters of 2–7, or sometimes single, sessile, not at all secund, 8- (rarely 5-) flowered; involucre narrowly campanulate or subcylindric, 5–7 mm. high, its scales puberulent, well imbricated in several ranks, the outer ovate-triangular, acute or apiculate, the inner becoming oblong and slightly narrowed to an obtuse or rounded tip; achenes densely hirsute, not mature in the specimens examined; inner pappus pale brown, 4–5 mm. long on the immature achenes.

Type collected by Forrest Shreve on Blue Mountain Peak, Jamaica, May 14, 1906, and deposited in the Herbarium of the New York Botanical Garden. Other sheets in the same herbarium are *Nichols 20*, from moist woods, Morce's Gap, altitude 5,000 feet, *Nichols 120*, from the summit of Blue Mountain Peak, and *E. G. Britton 3856*, from Sir John Peak.

Vernonia proclivis sp. nov.

Shrubby, about 2 m. high; stem sparingly branched, finely striate, glabrate or thinly puberulent; cauline leave sconspicuously reflexed, bright green above, pale green beneath, thin, elliptic-oblong, widest at or near the middle, 6–8 cm. long by 2–3 cm. wide, distinctly acuminate, entire, gradually narrowed or subacuminate at base, glabrous and finely glandular-punctate with transparent globules above and minutely black-punctate beneath; veins promi-

nent beneath; petioles 3–4 mm. long; rameal and bracteal leaves similar, but much smaller; inflorescence cylindrical or pyramidal, composed of numerous short, divaricate, irregularly branched cymes, forming a terminal panicle, and bearing each 4–10 sessile, crowded, 8-flowered heads near their tips; involucre narrowly campanulate, 4–5 mm. high, its scales erect, regularly imbricated in several ranks, thinly puberulent or glabrate, the outer ovate, with acute or apiculate tips, the inner oblong, slightly narrowed to a rounded tip; flowers purple to pale lavender; immature achenes densely pubescent; outer pappus pale brown, 0.4 mm. long, the inner brown, 4 mm. long.

Type, *Britton 102*, from Morce's Gap, near Cinchona, Jamaica, September 2–10, 1906, in the Herbarium of the New York Botanical Garden. Three other sheets in the same herbarium agree with it perfectly and are referred to the same species: *Marble 188*, from Cinchona, *E. G. Britton 3856*, from the Blue Mountains, and *Britton 4055*, from the Parish of St. Thomas. The latter was collected in March; the achenes are all discharged and the dry and brown involucre is widely open.

Vernonia reducta sp. nov.

Shrubby, freely branched above, height not stated; stem striate, glabrate below, becoming puberulent in the inflorescence; leaves spreading, firm, bright green above, paler beneath, narrowly elliptical-oblong or somewhat oblanceolate, broadest at or near the middle, the principal ones 4–4.5 cm. long by 1.2–1.6 cm. wide, sharply acute or subacuminate, entire or finely denticulate, gradually narrowed at the base, minutely puberulent on both sides and finely glandular-punctate beneath; petioles 2–5 mm. long; cymes numerous, terminating the stem and the upper branches, and forming a large loose pyramidal panicle; rameal and bracteal leaves resembling the cauline, but becoming narrower and smaller toward the ends of the branches, and finally barely exceeding the heads; heads crowded in clusters of 2–7, sessile or nearly so, not at all secund, 5-flowered; involucre narrowly campanulate or subcylindric, 5–6 mm. high, its scales puberulent on the back and regularly imbricated in several ranks, outer scales triangular, acute, and somewhat arachnoid-ciliate, the inner becoming oblong-linear, puberulent or glabrate, narrowed to an obtuse apex; achenes about 2 mm. long, hirsute; pappus rufescent, the outer series 0.5 mm., the inner 4–5 mm. long.

Type, *Britton 203*, from Sir John Peak, Jamaica, September

2–10, 1906, in the Herbarium of the New York Botanical Garden. Two other sheets in the same herbarium are *Britton 151*, from New Haven Gap, and *Shreve*, from Sir John Peak.

The seven species of the group may be distinguished by the following key:

A. Heads more or less secund, 11–18-flowered; involucre campanulate to hemispheric, distinctly spreading when press-dried; its scales loosely and irregularly imbricated in few ranks.

1. Principal leaves about 3 times as long as broad.
   - *a.* Heads 11–13-flowered; pappus brown. — *Vernonia divaricata.*
   - *b.* Heads 18-flowered; pappus white. — *Vernonia albicoma.*

2. Principal leaves twice as long as broad, or less.
   - *a.* Leaves broadly ovate-lanceolate, distinctly acuminate; exposed portion of inner involucral scales oblong; heads 18-flowered; cymes freely branched. — *Vernonia acuminata.*
   - *b.* Leaves broadly ovate, acute or subacuminate; exposed portion of inner involucral scales ovate; heads 11-flowered; cymes sparingly branched. — *Vernonia expansa.*

B. Heads not at all secund, 5–8-flowered; involucre narrowly campanulate or subcylindrical, even when press-dried; its scales rather uniformly imbricated in several ranks.

1. Leaves spreading or ascending, nearly or quite sessile, distinctly oblong-obovate or subrhomboidal, 30–50 mm. long, acute; heads 8- (rarely 5-) flowered. — *Vernonia pluvialis.*

2. Leaves proportionately narrower or larger, broadest near the middle, more or less acuminate.
   - *a.* Leaves elliptical-oblong, about 25×65 mm., conspicuously reflexed; heads 8-flowered. — *Vernonia proclivis.*
   - *b.* Leaves narrowly elliptical-oblong, about 14×45 mm., spreading; heads 5-flowered. — *Vernonia reducta.*

SPECIES-GROUP FRUTICOSAE

When a sheet of Santo Domingan material came to hand, identified by Dr. Urban as authentic *V. fruticosa* Sw., it was at once seen that the species was entirely distinct from *V. rigida* and from the whole group to which *V. rigida* belongs. It was also seen that its nearest congeners were to be found among some undescribed species from eastern Cuba, with which it is accordingly grouped. As in several other species-groups, the chief similarity between the species included is in the general habit. The most

striking common feature here is the broad, rugose or bullate leaf with reticulate venation, closely invested beneath by a dense tomentum. In the Jamaican species-group *Permolles*, with similarly bullate or rugose leaves, the pubescence is densely sericeous-hirsute rather than closely tomentose, and in *V. yunquensis* the character of the involucral scales separates the species at once. The seven species may be distinguished as follows:

I. Santo Domingan species; leaves oblong-ovate, truncate or subcordate at base, obtuse, repand; bracteal leaves not reduced; cymes very flexuous. *Vernonia fruticosa.*

II. Cuban species.

A. Inner involucral scales obtuse or rounded; leaves ovate-lanceolate. *Vernonia desiliens.*

B. Inner involucral scales sharply acute or acuminate.

1. Leaves oval to elliptic-oblong, obtuse or narrowed at the base, rugose and finely papillose-pubescent above.

a. Leaves more than half as broad as long, very blunt or rounded at the apex; straggling plant with white flowers. *Vernonia calophylla.*

b. Leaves less than half as broad as long, narrowed to an obtuse or subacute apex; plant erect, with light blue flowers. *Vernonia vicina.*

2. Leaves of a lanceolate or ovate type, broadest near the truncate or subcordate base, strongly bullate and rugose above.

a. Leaves acute or barely obtuse, gray-tomentose beneath; inflorescence loose; cymes elongated; inner involucral scales broadest just below the middle. *Vernonia neglecta.*

b. Leaves obtuse or rounded; inflorescence compact; cymes abbreviated; inner involucral scales broadest near the base.

* Leaves ovate-oblong, crenate or repand, brown-tomentose beneath; involucre densely pubescent; inner scales merely acute. *Vernonia calida.*

** Leaves broadly ovate or oval, entire or somewhat revolute, closely gray-tomentose beneath; involucre thinly pubescent or glabrate; inner scales sharply acuminate. *Vernonia semitalis.*

VERNONIA FRUTICOSA (L.) Sw. Fl. Ind. Occ. 3: 1323. 1806.

Stem very slender, freely and loosely branched, glabrous or puberulent in the inflorescence; leaves firm, ovate-oblong, 1–2 cm.

long by half as wide, obtuse or rounded at the tip, irregularly crenulate or subentire, rounded or subcordate at base, dark green and thinly but softly pubescent above, densely gray-tomentose beneath; petioles 1–2 mm. long; upper and terminal branches floriferous and strongly flexuous; bracteal leaves resembling the cauline in shape and size; heads single, sessile, 21-flowered; involucre broadly turbinate or campanulate, 5 mm. high, its scales all erect or somewhat spreading, very loosely imbricated, puberulent or glabrous, the outer subulate, the inner narrowly lanceolate and long-acuminate with a subulate tip; achenes hirsute; pappus nearly white, 4 mm. long.

For the identification of this obscure species of Swartz we are indebted to Dr. Urban. The description above is based on a single sheet, *Fuertes 655*, from the Province of Barahona, Santo Domingo, at 350 m. altitude.

Vernonia desiliens sp. nov.

Herbaceous, sparingly branched, 3–5 dm. tall; stem rather prominently striate, glabrous below, becoming puberulent in and near the inflorescence; leaves firm and coriaceous, ovate-lanceolate to narrowly elliptical, the largest on the type sheet 8–8.5 cm. long and 2.3–2.9 cm. wide, obtuse, entire or obscurely and shallowly crenulate, obtuse or rounded at the base, with petioles 1–3 mm. long, rugose, glabrous and shining above; veins elevated beneath and prominently reticulated, the principal lateral ones strongly ascending and almost parallel to the leaf-margin; the interstices of the reticulations closely gray-tomentose; cymes apparently one or two, terminal and from the upper axils, spreading, 1–2 dm. long, very flexuous; bracteal leaves resembling the cauline but narrower in shape and gradually reduced in size, oblong or narrowly elliptical, 3–5 cm. long, 5–12 mm. wide, spreading, those at the extremity of the cyme oblong-linear, 2 cm. long; heads sessile, single in the axils, 1–2 cm. apart, 21-flowered; corollas purplish; involucre turbinate, thinly pubescent, 9–10 mm. high; the lower outer scales short, minute, triangular, acute and apiculate, and closely imbricated; the inner scales much longer, linear-oblong, obtuse; achenes strigose-pubescent; pappus light brown, the inner series 6 mm. long, minutely barbellate, the outer series 0.5 mm. long, somewhat paler.

Type, *Shafer 3232*, growing among rocks near water, Arroyo del Medio, Oriente, Cuba, at 450–550 m. altitude, January 20, 1910, deposited in the Herbarium of the New York Botanical Garden.

Vernonia calophylla sp. nov.

A straggling shrub, 1 m. high or less; stem slender, striate, freely and loosely branched, cinereous-puberulent below, becoming tomentose in the branches; leaves firm and rigid, ovate to subrotund, the principal ones 20–25 mm. long by 13–18 mm. wide, rounded or obtuse at the apex, entire, somewhat revolute, rounded or subcordate at base, dark green, rugose, and papillose-pubescent above, closely invested beneath with silver-gray tomentum; veins conspicuous, the lateral ones ascending and the veinlets prominently reticulated; petioles 1–2 mm. long; heads in the axils of the upper leaves, forming cymes 10–16 cm. long, sessile, 18–21-flowered; bracteal leaves resembling the cauline, but smaller, 1–1.5 cm. long and more densely pubescent above; corollas white; involucre campanulate, 5 mm. high; scales somewhat arachnoid-puberulent, especially near their tips, the outer ones narrowly triangular, subulate, the inner linear-oblong, acute; achenes pubescent, 2 mm. long; pappus nearly white, the outer series 0.8 mm., the inner 4 mm. long.

Type, *Shafer 8102*, from Camp La Gloria, south of Sierra Moa, Oriente, Cuba, December 24–30, 1910, deposited in the Herbarium of the New York Botanical Garden.

Vernonia vicina sp. nov.

An upright shrub, 3–6 dm. tall, sparingly branched; stem finely striate, glabrate below, puberulent above, and in the branches closely cinereous-tomentulose; leaves firm and rigid, spreading, dark green above, elliptic to elliptic-oblong, the principal ones 3–4.5 cm. long by 1–1.5 cm. wide, broadest at or near the middle, narrowed to an obtuse or subacute tip and to an acute base, entire, somewhat revolute, rugose above, papillose-pubescent when young, becoming glabrate with age, closely invested beneath with thin yellowish brown or cinereous tomentum, especially between the veins; lateral veins ascending, but curved and approximate near the margin; veinlets prominently reticulated; petioles curved, 1–2 mm. long, tomentose; upper leaves like the lower, but smaller, eventually only 1 cm. long by 4 mm. wide, bearing heads in the upper 4–5 axils; heads about 26-flowered; flowers light blue, involucre campanulate, 5–6 mm. high, its scales closely imbricated, glabrous or thinly puberulent, outer scales subulate, somewhat spreading, inner scales lance-oblong, sharply acute; achenes pubescent, 2 mm. long; outer pappus white, 0.8 mm. long; inner series almost white, 4 mm. long.

Type, *Shafer 8202*, from Camp La Gloria, south of Sierra Moa,

Oriente, Cuba, December 24–30, 1910, deposited in the Herbarium of the New York Botanical Garden.

Vernonia neglecta nom. nov.

V. Wrightii Griseb. Cat. Pl. Cuba 144. 1866. Not *V. Wrightii* Sch.-Bip. 1863.

Vernonia gnaphaliifolia Gleason, Bull. N. Y. Bot. Gard. 4: 178. 1906. Not *V. gnaphaliifolia* Rich. 1850.

Apparently erect and suffruticose, sparingly branched, 6–15 dm. high; stem and branches slender, obscurely striate, finely gray-tomentulose; leaves firm, flat, spreading, narrowly ovate-oblong to ovate-lanceolate, the largest on the type sheet 6–7 cm. long by 2 cm. wide, acute, or subobtuse and minutely apiculate, entire, rounded, truncate, or even subcordate at base, dark green and bullate above, papillose-puberulent when young, becoming glabrous and shining at maturity, softly gray-tomentose or almost villous beneath, especially along the elevated, prominently reticulated veins; petioles tomentose, 1–4 mm. long; cymes 2 or 3, terminal, spreading, 1.5–2.5 dm. long, straight, leafy; lower bracteal leaves ovate-lanceolate or lanceolate, about 3 cm. long by 1.3 cm. wide; the upper reduced, becoming oblong and only 1.5 cm. long; heads sessile, secund, about 21-flowered, separated by internodes 1–2 cm. long; corollas purple; involucre broadly campanulate, about 6 mm. high, its scales rather closely but irregularly imbricated, thinly pubescent or glabrate, the outer triangular and subulate, the inner ovate-lanceolate, sharply acute, somewhat scarious on the margin; achenes pubescent, 1.5 mm. long; outer pappus white, 0.9 mm. long, the inner series very pale brown or almost white, 4 mm. long.

Type, *Wright 1309*, on banks of cliffs near Monte Verde, eastern Cuba, deposited in the Gray Herbarium of Harvard University. The specimen bears two labels, one dated "Dec. 27," the other "Jan.–Jul. 1859." On the left-hand side of the same sheet is another specimen of the same species, also numbered *1309*, and collected in eastern Cuba, Sept. 1859–Jan. 1860. Another sheet of the same species in the Gray Herbarium is *Wright 2788*.

Vernonia calida sp. nov.

Shrubby, freely branched, 5 dm. tall; stem obscurely striate, thinly puberulent or finely cinereous-tomentulose in the inflorescence; leaves spreading, thick, rigid, ovate-oblong, the principal

ones 3.5–5 cm. long and 1.5–2 cm. wide, obtuse or rounded at the tip, crenate or repand, broadly rounded or subcordate at base, strongly bullate, dark green, minutely papillose-pubescent when young, soon becoming glabrate or scabrellate and shining above, densely and softly brown-tomentose beneath; petioles 1–3 mm. long; lateral veins prominent, strongly curved and soon confluent; veinlets prominently reticulated; cymes few, simple or sparingly branched, 6–12 cm. long, the rachis densely tomentose; bracteal leaves resembling the cauline in shape, but smaller, crenulate or entire, the upper 1–1.5 cm. long; heads rather crowded, single or frequently two at each node, about 21-flowered, separated by internodes 1–2 cm. long; corollas pink; involucre broadly campanulate, 7 mm. high; scales densely pubescent, closely imbricated, or somewhat spreading at the tip, the outer subulate, the inner narrowly triangular-lanceolate and acute; achenes pubescent, 1.5 mm. long; pappus yellowish brown, the outer series 0.7 mm., the inner 5 mm. in length.

Type, *Shafer 8408*, in dry soil, Sabanilla to Yamuri Arriba, Oriente, Cuba, January 30, February 1, 1911, deposited in the Herbarium of the New York Botanical Garden.

Vernonia semitalis sp. nov.

Shrubby, 6–9 dm. tall, freely branched above; stem striate, leafy, thinly brown-tomentose, especially on the younger branches; leaves numerous and crowded, thick, rigid, somewhat revolute, divaricately spreading, ovate or ovate-triangular, broadest near the base, 1.5–2 cm. long by 1–1.3 cm. wide, obtuse or rounded at the apex, entire, truncate or subcordate at base; upper surface shining, glabrous or scabrellate, strongly bullate; lower surface closely invested with a thin gray-green tomentum; veins elevated beneath, the lateral ones ascending and confluent near the margin; veinlets prominently reticulated; upper leaves resembling the lower ones and scarcely reduced in size, bearing heads in their axils and forming several crowded cymes 10–15 cm. long; heads about 21-flowered, secund, the lower separated by internodes 1 cm. long, the upper approximate; corollas white; involucre campanulate, about 5–6 mm. high; outer scales triangular-subulate and pubescent, the inner narrowly triangular, sharply acuminate, glabrous or nearly so; achenes pubescent, 1.5 mm. long; pappus nearly white, the outer series 0.7 mm., the inner 4 mm. long.

Type, *Shafer 4176*, from pine land, altitude 400 m., along the trail from Rio Yamaniguey to Camp Toa, Oriente, Cuba, February 22–26, 1910, deposited in the Herbarium of the New York Botanical Garden.

SPECIES-GROUP SAGRAEANAE

This group is distinguished at once from other West Indian species by the large glabrous achenes. The leaves also are usually thick and firm or coriaceous, entire or with spinulose teeth. Most of the species have been in the past poorly represented in American herbaria, and some of them have been seldom collected since their original discovery.

In the revision, *Vernonia rigida* Sw. and *Vernonia fruticosa* (L.) Sw. were regarded as identical and referred to this group, to which the name *Rigidae* was applied. Since that time, specimens of *V. fruticosa* have again been collected, and the species is seen to belong to a different group. The Jamaican *V. rigida*, also, is described with pubescent achenes, a character which removes it at once from this group.

In 1836 De Candolle described *V. Sagraeana* from Cuba, the first known species of the group. This was followed in 1850 by *V. Valenzuelana* of Richard. In 1863 Schultz examined the recent Cuban collections of Wright, and added three species, *leptoclada*, *inaequiserrata* and *Wrightii*, and a fourth, *Sprengeliana*, based on a plant collected by Bertero in Santo Domingo. Grisebach added a variety, *inaequiserrata angustifolia*, also collected by Wright in Cuba. That left the group with seven species and one variety, and, so far as known to the writer, no authentic collection of any of these was made or at least recognized for forty years. Further difficulty was added by the confusion of numbers of some of Wright's collections, so that at least two different species have masqueraded in herbaria under wrong names. One case of this confusion was recognized in 1906 by Gleason, who remedied it by the description of *V. viminalis*.

Since 1906, the collectors of the New York Botanical Garden, in their diligent explorations of Cuba, have recollected four of these old, imperfectly known species, and have added three entirely new forms, which are here described.

The group as a whole is one of the most easily recognized of all the West Indian species. It is characterized especially by a high involucre and by large, glabrous, obscurely ribbed achenes, with a prominent basal callus, and the large, firm or rigid leaves.

I. Species of Santo Domingo; leaves oblong, very tomentose beneath, rugose and scabrous above, narrowly oblong, attenuate from the middle to a truncate or subcordate base; inner involucral scales rounded and apiculate at the tip. *Vernonia Sprengeliana.*

II. Species of Cuba.

A. Leaves thick, coriaceous, more or less revolute and shining above, oblong or ovate-lanceolate, remotely dentate or entire.

1. Heads 8-flowered; involucre cylindric. *Vernonia purpurata.*

2. Heads with 18 flowers or more; involucre campanulate.

a. Leaves narrowly oblong, at least three times as long as broad, entire, or with numerous minute spinulose teeth. *Vernonia Valenzuelana.*

b. Leaves broadly oblong, about twice as long as broad, entire, or with a few few remote but conspicuous teeth.

* Scales of the involucre all erect or barely spreading, the inner acute, the outer mucronate. *Vernonia leptoclada.*

** Outer scales conspicuously squarrose or reflexed, all sharply acuminate or subulate. *Vernonia Wrightii.*

B. Leaves thin or firm, but not coriaceous, flat, serrate, spinulose-denticulate, or entire.

1. Leaves puberulent or glabrous beneath.

a. Outer scales of the involucre short, acute or mucronulate, appressed. *Vernonia Sagraeana.*

b. Outer scales of the involucre elongated, subulate, spreading. *Vernonia aronifolia.*

2. Leaves tomentose beneath.

a. Middle involucral scales sharply acuminate, densely ciliate. *Vernonia viminalis.*

b. Middle involucral scales rounded to a mucronate apex, or acute.

* Inner scales obtuse or subacute; middle scales without scarious margin; leaves entire or obscurely spinulose-denticulate. *Vernonia fallax.*

** Inner scales apiculate; the middle with a scarious margin.

° Leaves narrowly linear-oblong, entire. *Vernonia ceratoides.*

°° Leaves narrowly elliptic-oblong, sharply serrate. *Vernonia inaequiserrata.*

Vernonia Sprengeliana Sch.-Bip. The type specimen cited by Schultz is *Bertero 507* and the recent description by Gleason is

based on a single sheet of *Wright, Parry, & Brummel 273*. An excellent collection of this rare species, *Fuertes 1388*, has been recently distributed and agrees perfectly with the original description and with that of Gleason (Revision, 184).

Vernonia purpurata sp. nov.

Shrubby, 2–2.5 m. tall; stem stout, coarsely striate, thinly tomentose below, becoming densely so in the inflorescence; leaves crowded, heavy, rigid, coriaceous, divaricate, elliptic-oblong, obtuse or subacute, entire or irregularly repand, obtuse or rounded at base, strongly rugose above, but glabrous and shining except for some thin pubescence along the midvein, minutely puberulent along the veins beneath; veins elevated on the lower surface, the lateral veins prominent, ascending, the veinlets small and closely reticulated; petiole 2–4 mm. long, tomentose; inflorescence small, irregular, composed of several short (2–6 cm.) leafy cymes, bearing each 4–10 heads; rameal leaves resembling the cauline, but two thirds as long; bracteal leaves narrowly oblong or oblong-linear, 10–15 mm. long, not present below many of the heads; heads sessile, secund along the cymes or aggregated at their tips, 8-flowered; corollas white; involucre narrowly cylindric, 6 mm. high; scales closely imbricated, appressed, sharply acute, the lower ovate-triangular, pubescent, the middle ones with an ovate-triangular exposed portion, ciliate, glabrous on the back, the inner entire, puberulent on the back, purple-brown at their exposed tips; achenes glabrous, immature in the type specimen; pappus pale yellow-brown, the outer series 1.3 mm., the inner 7 mm. long.

Type, *Taylor 544*, from Jiquarito Mountain, Sierra Maestro, eastern Cuba, altitude 1,020 m., September 18, 1906, deposited in the Herbarium of the New York Botanical Garden.

The lower leaves are lacking from the type plant. The crowded upper leaves are remarkably uniform in size, 4–5 cm. long by 1.5–1.9 mm. wide. On another branch is the base of a leaf which measures 3 cm. wide, indicating that the lower leaves are considerably larger than the upper. While the species certainly belongs to this group, it is distinguished from all the others known by its few-flowered heads.

Vernonia Valenzuelana Rich. A shrub 1.2 m. high, on dry ferruginous soil, southeast of Paso Estancia, Oriente, Cuba, *Shafer 1705*.

Vernonia leptoclada Sch.-Bip. A specimen agreeing perfectly with the original description has been recently collected by Shafer, *8145*, from Camp La Gloria, south of Sierra Moa, Oriente, Cuba. It is described as a straggling shrub 3.5 m. tall, with white flowers.

Vernonia Wrightii Sch.-Bip. *Ex descr.* A shrub, 1 m. high, freely branched above; stems pubescent; leaves heavy and coriaceous, spreading or ascending, ovate-oblong to oblong, 3.5 cm. long by 1.2 cm. wide, sharply acute or mucronate, revolute, entire or with a few remote spinose teeth, rounded or even subcordate at the base, very scabrous above but not pubescent, minutely puberulent under the lens beneath; petioles 1–2 mm. long, pubescent; cymes long and spreading, with numerous heads; bracteal leaves like the cauline, but gradually reduced to 1 cm. long; heads sessile, secund, about 21-flowered; involucre about 7–8 mm. high, outer scales ovate, acuminate into a squarrose or recurved tip, the inner erect or somewhat spreading, sharply acute or subulate; pappus pale brown.

Shafer 7738, from a dry serpentine hill near El Yunque, Oriente, and *Shafer 3072*, from pine lands at 500–650 m. altitude near Woodfred, Oriente, are referred here. They agree in most essential points with Schultz' description of *V. Wrightii* (Journ. Bot. 1: 234. 1863), but lack the glabrous leaves narrowed at both ends and the sordid-purple pappus.

Schultz' species is based on *Wright 1309*. As is well known, the Wright numbers are much confused, and frequently shelter more than one species. The only available specimen of this number belongs to an entirely different species.

Vernonia Sagraeana DC. A shrub 1.5 m. tall, growing on banks at an altitude of 325 m., near El Cuero, Oriente, *Britton & Cowell 12794*.

Vernonia aronifolia sp. nov.

Bushy, suffrutescent or shrubby, 12–15 dm. high; stem stout, freely branched, striate, finely and thinly tomentose, the tomentum increasing in density toward the tips of the branches and always most abundant in the axils; leaves dark green, thin but firm, obovate-oblong, about 8 cm. long by 4 cm. wide, abruptly acuminate, remotely denticulate with subulate or spinulose teeth 0.5

mm. long, standing at right angles to the margin, obtuse or subacute at base, minutely puberulent beneath, especially along the veins, glabrous above; veins prominent, light green, the lateral ones arcuate-ascending, branched and reticulated, especially toward the margin, one of the smaller marginal veins prolonged into each denticulation; cymes terminal and lateral, spreading, unbranched, 15–20 cm. long, very leafy, bearing 6–10 heads; bracteal leaves resembling the cauline in shape and texture, or varying to broadly oblong-elliptic in shape; the lower approximating the cauline in size, the upper gradually reduced to half the size, but always greatly exceeding the flowers; heads sessile, single in the axils, about 34–47-flowered; corollas white; involucre hemispherical or broadly campanulate, 8–9 mm. high, in dried specimens about 15 mm. broad; scales thinly puberulent, imbricated only at the base, straight or erect in bud, becoming spreading or flexed in fruit, the outer lance-linear, subulate, the inner linear-oblong, acuminate to a subulate tip; achenes smooth; outer pappus white, 0.8 mm. long, inner series pale brown or nearly white, 8 mm. long, minutely barbellate.

Type, *Shafer 13514*, collected from high rocks in limestone hills, vicinity of Sumidero, Province of Pinar del Rio, Cuba, August 2, 4, 1912, deposited in the Herbarium of the New York Botanical Garden. The collection is represented by two sheets, one including apparently the top of the plant, and the other two detached lateral branches.

Vernonia fallax sp. nov.

Shrubby, 1 m. high; stem erect, sparingly branched, finely striate, closely gray-tomentose, especially above; leaves firm, bright green above, elliptic-oblong, 5–7 cm. long by 2–2.5 cm. wide, acute, mucronate, entire or very obscurely and remotely spinulose-denticulate, narrowed to an acute base, thinly puberulent above, especially on the veins, finely and closely gray-tomentose beneath; veins elevated and prominent beneath, not conspicuously reticulated; petioles 1–2 mm. long; inflorescence pyramidal, terminal, of about 4–10 short, spreading or recurved cymes bearing each 3–7 heads; heads secund, sessile, about 21-flowered; involucre broadly campanulate or subhemispherical, 6–7 mm. high, its scales appressed, closely imbricated, pubescent, especially near the tip, outer scales ovate-triangular, acute and cuspidate, the inner subacute or rounded at the tip; outer pappus white, 0.7 mm. long, the inner pappus very pale brown, 6 mm. long; achenes glabrous.

Type, *Britton & Wilson 5478*, from a hillside, altitude 500 m., in the Trinidad Mountains, Province of Santa Clara, Cuba, March 12, 1910, deposited in the Herbarium of the New York Botanical Garden.

The bracteal leaves have all fallen off the type specimen, except a few fragments, and the leaves are crowded on short lateral branches. The inflorescence is thus left at the end of a naked peduncle 2–3 dm. long, giving the specimen an aspect entirely unlike other species of the group. It is scarcely to be expected that the same peculiarity will be maintained in other collections of the species.

Vernonia aceratoides sp. nov.

Vernonia inaequiserrata angustifolia Griseb. Cat. Pl. Cuba 144. 1866.

Slender and probably herbaceous; stem finely striate, closely gray-tomentulose; leaves firm, spreading or ascending, narrowly oblong-lanceolate or lance-linear, the principal ones 7–8 cm. long and 1–1.2 cm. wide, acute and mucronulate at the tip, entire or somewhat repand; obtuse or rounded at the base, minutely scabrellate above and puberulent along the midvein, finely brown-tomentulose beneath; veins prominent beneath and conspicuously reticulated; petioles 2–3 mm. long; inflorescence terminal, of about 3 short divaricately spreading cymes, bearing each six or seven secund heads; bracteal leaves oblong, the upper ones not exceeding the heads, and all proportionately broader than the cauline; involucre narrowly campanulate, 5–6 mm. high; scales closely and regularly imbricated, appressed, the outer ovate-triangular, cuspidate, the inner with an ovate exposed portion, rounded and apiculate at the tip.

Grisebach's variety was based on a specimen of *Wright 2784;* the preceding more detailed description is based on a sheet of the same number in the Herbarium of the Missouri Botanical Garden.

SPECIES-GROUP LONGIFOLIAE

The herbarium of Dr. Otto Kuntze contained a good specimen of a *Vernonia* from St. Thomas, collected by Kuntze himself in 1874, and labeled *Vernonia Thomae* Benth. It can not be distinguished, however, in any essential character from *Vernonia albicaulis* Pers., and the two species may henceforth be considered identical. This disposition of *V. Thomae* was suggested before by Gleason (Revision, 191), although at that time the two were

kept separate since good material for examination was lacking. The island of St. Thomas is accordingly added to the known distribution of *V. albicaulis*. It has been collected in St. Thomas by others also, and is represented in the herbarium of the Field Museum by two sheets, *Millspaugh 522* and *Eggers 34*.

Vernonia longifolia Pers. To the distribution of this species may be added St. Martin, *Boldingh 2641*, and Montserrat, *Shafer 172, 589, 659, 661*.

Lepidaploa, *Scorpioideae reductae*

Vernonia arctata Gleason. The species was originally described (Bull. Torrey Club 33: 185. 1906) from New Providence Island, of the Bahama group, but is now known to occur also throughout Andros Island, *Small & Carter 8506, 8613, 8759, 8890, Brace 5176, 6754, 6926, 7138*. Field data show that the flowers vary from purplish white to bright rose-purple and that the plant reaches a height of 2 meters.

Vernonia bahamensis Griseb. Reported by Gleason (Bull. Torrey Club 33: 187. 1906) from Fortune Island and Inagua, it is now represented also by specimens from Crooked Island, *Brace 4851;* Acklin's Island, *Brace 4330;* Salt Cay, *Millspaugh & Millspaugh 9249;* Long Cay, *Brace 4152, 4020, 4115;* Mariguana, *Wilson 7461;* Castle Island, *Wilson 7783;* Cotton Cay, *Millspaugh & Millspaugh 9362;* North Caicos, *Wilson 7721, Millspaugh & Millspaugh 9175;* East Caicos, *Millspaugh & Millspaugh 9082;* and South Caicos, *Wilson 7688*. The last specimen cited has leaves subacuminate or merely acute at the base, 5 cm. long by 2.5 cm. wide, and in general closely approximates *V. albicaulis* Pers. The *Scorpioideae reductae* have been considered (Gleason, Revision, 165, 166) as related by origin to the species-group *Longifoliae*, to which *V. albicaulis* belongs, and the theory is strengthened by the strong superficial resemblance just mentioned. It is interesting to note that *V. bahamensis* occupies the southeastern portion of the Bahama archipelago, nearest the area of the *Longifoliae*, and that the particular specimen comes from South Caicos, which is almost the extreme southeastern island of the group.

Vernonia complicata Griseb. In the type collection, *Wright 2790*, the leaves are all entire, subrotund, and about 5 mm. long.

An excellent specimen, *Britton 2225*, recently received at the New York Botanical Garden from Guantanamo Bay, in extreme eastern Cuba, has leaves of the same character on the old shoots, while on the young branches they are flat or undulate and 10–15 mm. long. The Guantanamo plant is described as a shrub 1 m. tall with purple flowers.

Lepidaploa, *Scorpioideae aggregatae*

Vernonia Thomae Benth., included here by Gleason (Revision, 191), is now regarded as identical with *Vernonia albicaulis* Pers. Urban (Symb. Antill. 7: 421. 1912) has recently added a species, so that the number in the group remains four. They may be distinguished as follows:

A. Achenes pubescent; outer pappus conspicuous, its scales much broader than the white bristles of the inner series; leaves 2–3 cm. long. — *Vernonia buxifolia* (Cass.) Less.

B. Achenes glabrous and glandular; outer pappus minute, its scales not sharply distinguished in width from those of the inner series.

1. Leaves tomentulose beneath; pappus strongly tinged with rose color; heads about 11-flowered. — *Vernonia Tuerckheimii* Urban.
2. Leaves minutely puberulent or glabrous beneath; pappus yellowish or tawny; heads 8-flowered. — *Vernonia montana* Gleason.

C. Achenes densely hirsute; outer pappus conspicuous, its scales chaffy and fimbriate; leaves 4–5 cm. long, closely gray-tomentose, and with prominent veins beneath. — *Vernonia yunquensis* Gleason.

The first three species are all very similar in habit and structure, and are all natives of Hispaniola. There is no doubt that they are closely related. The character of the pappus and the larger leaves indicate that *V. buxifolia* is the primitive form. The distribution (Cuba) and the general habit of *V. yunquensis*, especially of the leaves, as expressed in pubescence and venation, separate it sharply from the first three species, and imply that it may logically constitute another species-group.

Vernonia segregata sp. nov.

A straggling or vinelike shrub, reaching a height of 2.5 m.; stem obscurely striate, closely pubescent; the branches olive-

brown and finely tomentulose; leaves numerous, crowded, firm, dark green, oblong to elliptic-obovate, broadest at or above the middle, the principal ones 2.5–4 cm. long and 1–1.5 cm. wide, obtuse or subacute, entire, obtuse or rounded at the base, scabrellate and resinous-punctate above, glabrous beneath and densely punctate with resinous globules and impressed black glands; midvein puberulent, the lateral veins inconspicuous; petioles 1–2 mm. long; inflorescence terminal, irregular in shape, consisting of several short, simple or sparingly branched cymes 2–4 cm. long, naked below, and bearing 2–8 crowded heads in a terminal subcapitate cluster, or at the base of the branches; bracteal leaves 1–3 subtending each cluster of heads, resembling the cauline in shape, 5–15 mm. long; heads about 8-flowered; corollas white; involucre campanulate, 3–4 mm. high, its scales loosely and irregularly imbricated, appressed at the base, but spreading at the tip, stiff and firm in texture, the outer narrowly triangular-lanceolate, long-acuminate, the inner narrowly oblong-linear, tapering gradually to the acuminate puberulent apex; achenes thinly pubescent, 2 mm. long; pappus nearly white, the outer series 1 mm., the inner 4 mm. long.

Type, *Shafer 4050*, from rocky river banks in the vicinity of Camp San Benito, Oriente, Cuba, altitude 900 m., February 24, 1910, deposited in the Herbarium of the New York Botanical Garden. Other sheets in the same herbarium, all collected in the mountains of Oriente, are *Shafer 8051*, stated to be vinelike and 8 feet high; *Shafer 8216*, 1.5–2 feet high; and *Shafer 4446*, described by the collector as an herb three feet high with purple flowers. Notwithstanding field differences in the color of flowers or texture of stem, all four numbers clearly belong to the same species.

The relationship of *V. segregata* is puzzling. The subcapitate clusters clearly represent a modification of a scorpioid type, and most closely resemble the inflorescence of the *Scorpioideae aggregatae*. The involucre is quite different, however, from that of typical members of the group. For the present, it has been considered advisable not to assign the species to any group.

SPECIES-GROUP HAVANENSES

In recent work on *Vernonia*, *V. havanensis* and *V. Ottonis* have been considered identical (Revision, 192). The large series of specimens now available for study permits the ready separation of two species, with characters so typical that to each can be

assigned the proper specific name without difficulty. In addition, a new species has been collected by Shafer and is described below.

With the exception of *V. pallescens*, whose position in this group is somewhat uncertain, the group is distinguished by similarities in habit. The leaves are of a comparatively broad type, widest near or usually above the middle, and with the serration most prominent on the distal half. The involucre scales are regularly pubescent in two areas on the back, one on each side of the mid-nerve.

The four species may be distinguished as follows:

A. Inflorescence strictly scorpioid; the cymes many-headed and elongated; heads all sessile. *Vernonia pallescens.*

B. Inflorescence freely branched and subpaniculate, some of the heads pedicellate; leaves with a tendency to be broadest above the middle; scales glandular on the back, especially on each side of the mid-nerve.

1. Heads with 18 flowers or more; involucres 5–8 mm. high, or some of the scales 10 mm. long, distinctly purple-tinged; leaves essentially glabrous on both sides; pappus white, or with a faint brownish yellow tinge. *Vernonia havanensis.*

2. Heads 5–13-flowered; involucres 3–4 mm. high, obscurely or not at all tinged with purple; leaves scabrous above; pappus pale brown.

a. Heads 11–13-flowered; inner scales obtuse or subacute; inflorescence divaricate. *Vernonia Ottonis.*

b. Heads 5-flowered, aggregated in subcapitate clusters at the ends of the branches, forming a pyramidal or subhemispheric inflorescence; inner scales acute. *Vernonia Orientis.*

Vernonia pallescens Gleason. The species certainly differs phylogenetically from the rest of the group, as shown by its inflorescence and its geographical distribution. It is included in the group merely for lack of a better place to put it.

VERNONIA HAVANENSIS DC. Prodr. 5: 37. 1836.

Vernonia stictophylla Wright, Sauv. Anal. Acad. Ci. Habana 6: 176. 1869.

The specimens at hand fall into two groups, the first with leaves long-attenuate at base, almost sessile, and thin in texture; the second with leaves cuneate into a distinct petiole and firm in texture. No other characters for their separation have been

found. The first group includes the type collection for Wright's species. Both series have been collected, so far as data are given, in the province of Pinar del Rio.

VERNONIA OTTONIS Sch.-Bip. Linnaea **20**: 508. 1847.

Vernonia hieracioides Griseb. Mem. Am. Acad. **8**: 511. 1860.
Vernonia cubensis Griseb. Cat. Pl. Cuba 144. 1866.

Except one collection from Santa Clara (*Leon 1315*) and one from the Isle of Pines (Curtiss), all the sheets examined are from Pinar del Rio. They show considerable variation in the pubescence, serration, and texture of the leaves, but can not be further separated. The specimens include cotypes of both Grisebach's species, and agree perfectly with Schultz' description.

Vernonia orientis sp. nov.

Shrubby, as much as 6 m. in height, apparently not extensively branched; stem coarsely striate, glabrate below, becoming cinereous-puberulent in the inflorescence; leaves rigid, dark green, spreading, oblanceolate, the principal ones 9–11 cm. long by 2.5–3.5 cm. wide, abruptly short-acuminate or sharply acute, remotely dentate with sharp salient teeth, chiefly above the middle, attenuate from below the middle to a cuneate base, very scabrous above, minutely puberulent and scabrellate beneath; veins elevated below, only the midvein and its lateral branches prominent; petioles 5–10 mm. long; inflorescence terminal, broadly pyramidal or subhemispheric; cymes freely branching, ultimately bearing 2–6 heads aggregated or subcapitate near the tips; bracts subulate, 3–5 mm. long; heads 5-flowered; involucre 3–4 mm. high, campanulate; scales ovate to ovate-oblong, sharply acute or subacuminate, essentially glabrous but glandular on the back; achenes sparingly pubescent; outer pappus minute, the inner pale yellowish brown, 4 mm. long.

Type, *Shafer 3509*, from Sierra Nipe, near Woodfred, Oriente, Cuba, altitude 450–550 m., January 10, 1910, deposited in the Herbarium of the New York Botanical Garden.

The two collections, both from Oriente, are the only examples of the group from this part of the island. It is distinguished from the other members of the group at a glance by its inflorescence, and also by the involucral scales and the number of flowers.

Lepidaploa, *Paniculatae dichotomae*

VERNONIA MENTHAEFOLIA (Pöpp.) Less. Linnaea 4: 268. 1829.
Eupatorium menthaefolium Pöpp. in Spreng. Syst. 3: 412. 1826.
Vernonia Grisebachii Sch.-Bip. Jour. Bot. 1: 231. 1863.

The original description of this species by Pöppig is too brief to be of any value at the present time. But his specimens were preserved, and examined later by both Schultz and Lessing. Lessing gives a detailed description, based on these types, stating that the heads are many-flowered and 3 lines high. Schultz' description, referring without doubt to the same specimens, or to duplicates of them, indicates that the heads are 11-flowered and the involucre hardly 1 line high. He then described *V. Grisebachii*, as cited above, to include the forms with large heads, based on *Wright 1305*. Examination of an ample series of specimens at the present time reveals but one species, agreeing with Lessing's and Schultz' descriptions, but never with the small heads ascribed by the latter to *V. menthaefolia*. In the series examined are two of Wright's collections, *282* and *2792*, and *Shafer 8811*, which was found by Dr. Britton to agree with the specimen of *Wright 1305* in the Kew herbarium. Throughout the series the heads have 11 to 18 flowers, and the involucres are 4–5 mm. high. The leaves show considerable variation, from narrowly oblong-lanceolate, acuminate at both ends, to ovate, rounded at the base and acute at the apex. These characters are not sufficiently definite or constant to permit the recognition of two species.

V. menthaefolia is the most abundant species of the genus in Cuba, judged from the frequency of its collection, and occurs throughout the island.

Among recent accession to the Herbarium of the New York Botanical Garden is an *Eremosis* from the state of Durango, which differs distinctly from all the fifteen described species of the genus.

Eremosis ovata sp. nov.

Shrubby; height and habit not stated; stem obscurely striate, closely cinereous-pubescent, becoming tomentulose in the inflorescence; leaves thick, firm, ovate to ovate-elliptic, 7–10 cm. long, 4–5 cm. wide, obtuse or subacute, entire, obtuse at base, dull green, minutely and softly tomentulose above, densely cinereous-

tomentose beneath; veins elevated below, the lateral ones prominent and ascending, the veinlets inconspicuous; petiole 8–13 mm. long; inflorescence broadly pyramidal or hemispheric, about 2 dm. wide; rameal leaves elliptic, about 2–6 cm. long, otherwise like the cauline; heads 4-flowered, in clusters of 3–8, on pedicels 2–5 mm. long; involucre narrowly campanulate, straw-colored or pale brown, 5–6 mm. high, outer scales short, broadly ovate, obtuse to subacute and apiculate, irregularly arachnoid or tomentulose, inner scales deciduous, oblong or ovate-oblong, acute, glabrous, or with minute patches of thin tomentum near the tip; achenes pale brown, 3 mm. long, prominently ribbed, thinly hirsute with ascending hairs; pappus white, 8 mm. long, the outer series much shorter.

Type, *Palmer 139*, from San Ramon, Durango, Mexico, deposited in the Herbarium of the New York Botanical Garden.

In general habit and shape of leaf, *Eremosis ovata* most closely resembles *Eremosis Steetzii* (Sch.-Bip.) Gleason, but is distinguished at once from this one-flowered species by its four-flowered heads. Its nearest relatives are probably to be found among the three-flowered species, such as *Eremosis Palmeri* (Rose) Gleason, from which it differs in the broad ovate leaves and dense tomentum.

The presence regularly of four flowers in each head is a peculiar feature, hitherto unknown in the genus. It is paralleled in a way, however, by the occurrence of two flowers instead of one in the heads of certain specimens of *Eremosis tarchonanthifolia* (DC.) Gleason.

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Some toxic and antitoxic effects in cultures of Spirogyra *

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In view of difficulties commonly experienced in maintaining algal cultures in the laboratory, it seemed desirable to make an experimental study of some of these difficulties, as was suggested to the writer by Professor Georg Klebs, and the present publication deals with a portion of such a study. The experimentation was carried out in the Botanisches Institut at Heidelberg in 1909 and 1910, the facilities of these laboratories being made available through the kindness of Professor Klebs. The experiments to be considered below bear upon the preparation of a nutrient solution suitable for algal growth under laboratory conditions, and undertake a partial analysis of the relations of the aqueous medium to the success or failure of algal cultures in glass.

The alga used for this study was *Spirogyra longata* (Vauch.) Kg.,† brought from Algiers in the spring of 1906 and kept since then (until the winter of 1909–10) in a north window of the Botanisches Institut at Heidelberg, with only small additions of tap water from time to time. At the time of beginning these studies the culture was healthy and showed vigorous growth, and the material seemed excellently suited for experimentation of the sort in hand; all the filaments had developed under closely similar conditions and were obviously adjusted to the conditions existing in the laboratory. In the experimentation it was thus possible to alter the culture medium without greatly changing the other environmental factors—*e. g.*, light, temperature—under which the plants had developed. The last consideration is an important

* Botanical Contribution from The Johns Hopkins University, No. 29.

† Determined from Einfachste Lebensformen des Tier- und Pflanzenreiches, Eyferth, B., 3 Aufl. 1900.

one; results obtained with material brought from various other conditions to the laboratory cannot be interpreted as caused by changes in the nature of the culture solution alone, a point well emphasized by some of the considerations to be brought out below.

The method here followed was to transfer a few (about 30 to 50) filaments from the stock culture to about ten cubic centimeters of the medium to be tested, in a covered glass dish. These transfers were made late in the afternoon, and the cultures were subjected to microscopic examination, without removal from the culture dishes, on the next morning and on succeeding days until final results were obtained. The experiments lasted for periods of from one to eighty-six days. The condition of each culture was recorded in the following terms. *Excellent* means that, at most, only a few cells showed injury; *good*, that considerably more than half of the filaments seemed uninjured; *poor*, that more than half were injured; *dead*, that practically every cell was dead. The tables used in this paper have been constructed from the daily records by stating in similar terms the general condition of the cultures throughout the experiments.

Precautions were of course taken to have the dishes and instruments as clean as possible. Any dish once used for a poisonous solution was discarded at the end of that experiment, and dishes were sometimes interchanged and furnished with fresh supplies of the media to be tested. The different lots of special distilled water did not enter into experiments until they had been found to be harmless to the plant here used. In most cases about the same amounts of media were used in the different experiments; the quantity of solution as related to the number of cells in any culture is to be considered as an important factor in all experiments bearing upon the relation of the nature of the medium to the behavior of organisms existing therein.

I. NUTRIENT SOLUTIONS

The nutrient media used were all prepared according to the formulae given by Küster (10), being those of Sachs, Knop, Molisch, and Crone.* These were afterward diluted to the

* These solutions contained salts in the following proportions:

required concentration with either ordinary or nontoxic distilled water. The reactions to litmus paper of the solutions thus prepared were as follows: Sachs's, very slightly acid; Knop's, acid; Molisch's, slightly acid; Crone's, neutral. The salts used were, in every case, those of Merck.

The results obtained from the various cultures in these nutrient solutions are given in TABLE I, where each culture is denoted by a letter indicating the condition of the culture during the period of the experiment, the number of letters thus denoting, in each case, the number of times that the experiment in question was performed. The durations of the cultures are also given. The same notation is used in TABLES II, III, and V.

Using nontoxic distilled water, prepared in a manner to be described later, the best growth was shown with all the media in concentrations containing from 0.05 to 0.1 per cent of total salts. In these concentrations of the solutions of both Molisch and Crone, *Spirogyra* was kept growing vigorously, in apparently perfect condition, for a period of about two months, at the end of which time the experimentation was discontinued. Crone's solution seemed slightly more favorable to the organism than did that of Molisch; Sachs' solution produced a fair growth; while Knop's medium was distinctly unfavorable, probably because of the marked acidity, free acid being injurious to many algae (10). No doubt still other media might prove as favorable as those of Molisch and Crone.

When ordinary distilled water was used in preparing the solutions a good growth was never obtained, but the results in both Molisch's and Crone's solutions seemed slightly better in concentrations of from 0.5 to 1 per cent than in weaker solutions. This will be discussed later.

The addition of one per cent of agar to the nutrient solutions, the *Spirogyra* filaments being laid on the surface of the coagulated

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SACHS	KNOP	MOLISCH	CRONE
1 g. KNO_3,	1 g. $Ca(NO_3)_2$,	1 g. $(NH_4)_2HPO_4$,	1 g. KNO_3,
0.5 g. NaCl,	0.25 g. KNO_3,	0.5 g. KH_2PO_4,	0.5 g. $MgSO_4$,
0.5 g. $CaSO_4$,	0.25 g. $MgSO_4$,	0.5 g. $MgSO_4$,	0.5 g. $CaSO_4$,
0.5 g. $MgSO_4$,	0.25 g. KH_2PO_4,	0.5 g. $CaSO_4$,	0.25 g. $Ca_3(PO_4)_2$,
0.5 g. $CaHPO_4$,	0.125 g. KCL,	Trace $FeSO_4$.	0.25 g. $Fe_3(PO_4)_2$.
Trace $FeCl_2$.	Trace $FeCl_2$.		

medium in a covered Petri dish, produced slight improvement in all the 0.1 per cent solutions from ordinary distilled water. A good growth was obtained on similar agar plates prepared from 0.5 per cent solutions (in ordinary distilled water) according to the formula of Sachs, of Molisch, and of Crone.*

Since the solutions here employed were all prepared from water and salts, it will be expedient to present the following considerations under the two headings: (II) Water and (III) Salts.

II. WATER

Many authors have found that tap water and distilled water are toxic to organisms, an excellent review of the literature of this subject being given by Livingston (12). Most workers have attributed the toxic effects of ordinary distilled water to small amounts of various metals—especially copper—taken by the water from the still and from the supply pipes. Lyon (19) and Bullot (6), however, found that water distilled in glass was markedly toxic, thus indicating that part of the poisonous action may be due to the presence of volatile substances. Lyon attributed this effect to small quantities of ammonia in the water. Similarly Livingston (12) showed that redistillation from glass to glass, while improving the quality of his ordinary distilled water, did not render it harmless. He obtained evidence indicating that part of the toxic bodies present in ordinary distilled water thus redistilled are volatile and reappear in the distillate, while part are nonvolatile and remain in the undistilled residue. The same writer prepared nontoxic water by shaking ordinary distilled water with highly absorbent solids, especially with purified lamp black, and then filtering out the solids. He concluded that the solids had absorbed, or at least removed from solution, both the volatile and the nonvolatile toxic substances.

In the present investigation both tap water and ordinary distilled water were found to be markedly toxic to *Spirogyra*, and were subjected to various treatments in an effort to obtain some evidence concerning the nature of the poisonous substances involved. The tap water was drawn from the faucet of the laboratory

* Knop's solution was so acid that 1 per cent agar would not harden in a 0.5 per cent concentration of the medium.

supply, directly into the culture dishes. The distilled water used was from the usual supply of the laboratory, obtained from a local druggist. It had been distilled in a copper still and kept in glass. All such water used in these experiments was from the same original supply and may thus be considered as uniform. The results obtained in the study of the physiological properties of various waters are given in TABLES II and III.

Tap water was usually fatal to the plant within a few days, although its toxicity varied slightly at different times (II, 1*). This water, when distilled with glass boiler and glass condenser, was as toxic as the untreated water (II, 2). The distillate was then sampled at different times during the run, by placing culture dishes at the outlet of the condenser and allowing them to receive the water directly; the alga was introduced into these water samples after they had cooled. Samples collected at the beginning and end of the run were as toxic as the untreated water (II, 3, 3*b*). About the middle of the run the distillate collected was found to be decidedly less injurious than the untreated tap water (II, 3*a*). Concentration of the tap water to one tenth its original volume by boiling (II, 4) and also by allowing evaporation to proceed at a temperature much below boiling, till only about a sixth of the original volume remained (II, 5, 6), produced marked improvement over the original untreated water, but concentration by evaporation to one third of the original volume did not improve its quality (II, 7). It will be noted, however, that the untreated water of this particular test was more toxic than in the two former experiments. In general, concentration seems to have improved the quality of the water, probably by driving off some of the volatile toxic substances, though it is of course not to be forgotten in this connection that the nonvolatile constituents were much more concentrated in the treated water than in the original.

The effect of high temperature without concentration was also tested. Heating tap water in the autoclave for 15 minutes, at a temperature of 144° C., destroyed all the toxic material, or else rendered it nontoxic; in water thus treated *Spirogyra* filaments remained in perfect condition for a month, while in untreated

* Roman numerals followed by Arabic, in parentheses, refer to table and experiment, respectively.

water drawn from the tap at the same time, nearly all the filaments succumbed within a few hours (II, 8). Heating tap water to a temperature of 100° C. in a steam sterilizer for 45 minutes produced no improvement; the filaments of *Spirogyra* died almost as quickly in this as in untreated water (II, 9).

Treatment of the tap water of the Heidelberg supply by the method of shaking with finely divided carbon, as employed with such marked effect by Livingston in the preparation of culture media from his ordinary distilled water, produced no improvement. In this treatment Merck's "animal charcoal" was employed as absorbing solid, without preliminary treatment of any sort. While it seems probable that there may be essential differences between the various forms of finely divided carbon now upon the market, as to their efficiency in the water treatments here considered, no comparisons have been made in this regard. The form here used was chosen merely because of its convenience.

Although, as has been pointed out, simple distillation of the Heidelberg tap water from glass into glass failed to correct the toxicity of the water, it was found that this same process of distillation rendered the water nontoxic to the *Spirogyra* here employed (II, 10) *when animal charcoal was present in the retort during the distillation.* In this treatment the boiler was a flask of Jena glass having a capacity of one liter; the condenser was of glass, provided with a bend to prevent the entrance of spray from the boiling liquid and thoroughly washed by use; and the receiver was a flask of Jena glass. No cork or rubber or material other than glass was used on the condenser. The usual charge was about 800 cc. of tap water with from five to ten grams of Merck's animal charcoal. Boiling was not allowed to become very violent and the process was stopped when the charge had been reduced to about one eighth of its original volume. In water thus prepared *Spirogyra* filaments remained in apparently healthy condition until the appearance of injury from lack of nutrient salts.

This method of distillation from animal charcoal showed some variation in the quality of the water produced (II, 10), but the differences exhibited were not as great as those obtained with different portions of water from the stock culture (III, 36). The water distilled from charcoal was frequently tested throughout

the experiments,—by determining its effect, when used alone, upon *Spirogyra* filaments. Out of more than ten runs the distillate from but a single one was found to be decidedly toxic to the alga. The cause of this single failure was not investigated. The new method was uniformly employed for the preparation of nontoxic water throughout the course of these studies.

Several experiments were carried out to throw light upon the question of the manner of operation by which distillation from animal charcoal may produce such a marked effect upon the physiological properties of the Heidelberg water. Not only the distillate but also the undistilled and concentrated residue (after removal of the charcoal by filtration through paper) showed marked improvement as compared with the untreated tap water (II, 11, 12). Furthermore, a high degree of toxicity was produced in the practically nontoxic water, either of the filtered residue or of distillate, by the addition of a portion of the used charcoal that had been retained in the filter (II, 11*b*, 12*a*, 12*c*).

From the above observations it appears clear that the animal charcoal in the boiler of the still must have acted to remove toxic substances from the water, although, as has been stated, such action could not be detected at ordinary temperatures. It also appears that charcoal which has been the agent in this removal of injurious material becomes itself able to reproduce toxic properties in nontoxic water to which it may be added. It may be therefore considered as at least highly probable that the action of the finely divided carbon of these distillation experiments was that of an absorber rather than that of an oxidizing or other catalytic agent. Of course it is open to question, whether the toxicity reproduced in harmless water by used animal charcoal may be caused by the same substances as was the original toxicity of the tap water before treatment. The state of our knowledge of these matters precludes their further analysis at this time.

One experiment was made to show the relative resistance to the toxic influence in tap water of two portions of *Spirogyra* which were originally from the same source but which had been subjected for a time to different conditions. One sample was taken from the stock jar and another from a vigorous culture which was originally from the stock culture and then had grown for the last 68

days in 0.1 per cent Crone's solution. The two samples contained approximately equal numbers of filaments. They were well rinsed in nontoxic water and then placed together in untreated tap water in a covered glass dish. Within a few hours the filaments from the stock jar showed decided injury, and, at the end of six days, when the experiment was discontinued, about one third of them were dead (II, 13). The filaments transferred from Crone's solution showed no signs of injury during the period (II, 14). This experiment emphasizes the facts, well recognized, but not always considered by workers with cultures, that the internal conditions of organisms are fully as important in determining their behavior as are the conditions of the surroundings, and that the past history of organisms (the sort of surroundings under which they *have* lived) greatly influence their internal nature. Comparable results cannot be expected, in such work as this, unless the living material used has been kept under uniform conditions for a considerable time previous to experimentation.

Turning to the results obtained with ordinary distilled water (TABLE III), this was found to be extremely toxic, killing all the filaments of *Spirogyra*, except in a single instance,* in from one to nine days (III, 1). Redistilling this water in glass produced a decided improvement in some cases, but none in others (III, 2–6). Similarly, the samples of water obtained as above described, at the beginning, middle and end of the distillation run, varied greatly and inconsistently among themselves. The undistilled portion left in the boiler after redistillation had been stopped was always just as toxic as untreated water (III, 2*a*, 3*c*, 4*e*, 5*e*). Making from the distillate or from the undistilled residue (III, 4, 5) a 0.5 per cent concentration of Crone's solution produced no improvement, so that this addition of nutrient salts failed to counteract the toxicity of these two waters. The addition of animal charcoal to the boiler during redistillation in glass usually produced no improvement over the water redistilled without the solid (III, 7, 8). Furthermore, the undistilled residue from such redistillation (after removal of the carbon) showed no marked improvement. Boiling with or without carbon (III, 2–10) is thus seen to have produced

* In this case an unusually small amount of distilled water was used, in proportion to the number of filaments in the culture.

no correction of the toxic conditions of ordinary distilled water. Heating in an autoclave for 15 minutes at 144° C. made ordinary distilled water decidedly less injurious, but did not render it entirely nontoxic (III, 11).

Dilution with an equal volume of physiologically pure water (III, 12) or with water from a vigorous culture of *Nitella* (III, 13) did not make the ordinary distilled water less toxic, but dilution with an equal volume of a colloidal platinum solution (III, 14) rendered this water less injurious.*

The addition to ordinary distilled water, at the time of adding the alga, of filter paper (III, 15), cotton (III, 16), kaolin (III, 17), quartz sand (III, 18), or small amounts of chalk (III, 19, 20), produced no improvement; but the addition of abundant chalk (III, 21), lime (III, 25), broken agar sticks (III, 27), or dry sphagnum moss (III, 31) usually rendered the water nontoxic. *Spirogyra* filaments died within a few hours in ordinary distilled water to which a small amount of agar solution was added (III, 28), they lived nearly two months on the surface of a 1 per cent. solution of agar made with this same water (III, 29), but died within three days on the surface of a 2 per cent agar solution (III, 30). In ordinary distilled water shaken with chalk (III, 22), wood charcoal (III, 23), or garden soil (III, 24) and decanted after the subsidence of the solid, little or no improvement was observed at first, but decided improvement was shown after a few days. Addition to the water of sediment from a vigorous culture of *Nitella* (III, 32) produced better growth than that occurring in untreated water, while sediment from the stock culture of *Spirogyra* (III, 33) produced no improvement.

It was found that the alga filaments themselves may exert a profound influence upon the toxicity of the solution in which they are immersed. A transfer of filaments was made, in the usual manner, from the stock culture to a dish of ordinary distilled water (III, 34). These filaments were dead within eighteen hours. They were then removed from the culture and replaced by a new transfer of filaments from the stock culture. These also died within eighteen hours, and were replaced as before. The third

* This colloidal platinum solution was kindly prepared by Dr. W. Fraenkel in the laboratory of Prof. G. Bredig. It contained 0.0096 g. of platinum per 100 c.c.

transfer was killed in about two days, and the material which then replaced it lived fifteen days, but was in apparently poor condition at the end of that time and was replaced. The material of this fifth transfer preserved an apparently healthy condition for forty-four days, at which time the experiment was discontinued. The toxic water had been rendered nontoxic simply by treatment with alga filaments. A clearer example of the effects of plants in removing or counteracting the toxic substances of a solution would be difficult to imagine. Similar results were obtained by Dandeno (7) upon growing corn seedlings in toxic solutions of HCl and H_2SO_4.

Toxic water may be greatly improved for *Spirogyra* by previous treatment with another alga. A mass of *Ulothrix* (with a few *Spirogyra* filaments) was allowed to remain twenty-eight days in ordinary distilled water (III, 35), while a control of a similar dish with another sample of the same water, but without alga, stood beside the first. At the end of this period the *Ulothrix* was removed and *Spirogyra* from the stock culture was transferred to each of the two dishes. In the water which had been previously treated with *Ulothrix* the *Spirogyra* lived, albeit in rather poor condition, for twenty-two days, while in the untreated water of the control all filaments were killed within eighteen hours.

In connection with the above observations on the effectiveness of alga filaments in correcting the toxicity of ordinary distilled water, it should be noted that, in all these experiments, the amount of *Spirogyra* added, in proportion to the amount of medium employed, exerted a considerable influence upon the results. A large amount of the alga was able to live in a small amount of a decidedly toxic medium. In all such cases the filaments on the outside of the mass were killed while those within remained in good condition. Similar results have been obtained by Nägeli (20), Deherain and Demoussy (8), Bullot (6), Dandeno (7), and Bokorny (3). In the same connection, water from the stock culture of *Spirogyra*, tested by the method used in these experiments, allowed a good growth (III, 36), but seemed less favorable than the water from a vigorous culture of *Nitella* (III, 37).

Although some of the experiments which have been considered were not repeated as many times as might be desirable, the different

experiments appear to corroborate each other, and seem to throw some light on the general nature of the toxic substances present in these waters. It will be noticed that the effect of distillation and of high temperature was often different in the case of tap water and in that of ordinary distilled water. Some of these differences are summarized in TABLE IV, where a plus sign indicates *improvement*, a minus sign indicates *no improvement*. When both signs occur, different tests were in disagreement.

The facts of TABLE IV indicate that the toxic materials present in the tap water and in the ordinary distilled water here studied were, in part at least, different substances; whatever may have been the nature of these substances those in the ordinary distilled water were mainly very resistant to heat.

As to the general characteristics of the toxic substances in the ordinary distilled water, there appears no reason for doubting that they were probably, for the most part, metallic in their nature, derived in some way from the distillation apparatus. This is the conclusion reached by many authors who have studied the toxicity of ordinary distilled waters since the time of Nägeli, and such supposition introduces no difficulty in the interpretation of the experiments that are reported here; it might be expected that metallic poisons, whether dissolved as salts or ions or existing merely in suspension, would not be very sensitive to correction by heat. The effect of redistillation might be to transfer a portion of the poisons from retort to receiver, thus leaving the distillate more or less toxic, and at the same time concentrating another portion (nonvolatile with steam and not sensitive to the temperatures employed) in the retort.

It has been shown by Livingston *et al.* (11), Livingston (12), Wheeler and Breazeale (37), Schreiner and Reed (27, 28, 29), Shorey (30, 31), and Lathrop (26), that certain organic substances present in various soil extracts are toxic to wheat seedlings. Since, as was pointed out by Livingston (12), tap water may be considered as a natural soil extract, the possibility is suggested that it may be toxic on account of poisons derived from the soil. At the same time, it is of course probable that the toxicity of the Heidelberg tap water here tested may have been due, to a greater or less extent, to substances having their origin in the supply pipes.

It may be supposed that somewhat complex poisons emanating from the soil would be largely volatile (either as such or as their decomposition products, *e. g.*, ammonia), and would thus be removed from the retort in the process of distillation. If such volatile material were still toxic and were retained in the receiver, the distillate would of course exhibit toxic properties. But the logical possibilities are here very numerous and a more detailed *a priori* consideration of this problem would be out of place without much more thorough experimentation than is now available.

The toxicity of the waters here dealt with was probably due, in every case, to more than one substance; different portions of tap water varied in their injurious effects, different portions of ordinary distilled water were differently affected by redistillation in glass, and other lines of evidence might be deduced from the present studies to indicate that both waters contained more than one kind of injurious material.

It appears highly probable that the beneficial effect on the ordinary distilled water of chalk, lime, agar, sphagnum moss, soil, and finely divided carbon, was due to their adsorptive action, a conclusion similar to that reached in the work of Nägeli (**20**), Breazeale (**5**), Livingston *et al.* (**11**), and Livingston (**12**). In some cases all the poisonous substances seem to have been removed from solution, for the treated water was entirely nontoxic. The nontoxic water obtained by the distillation of tap water from animal charcoal contained more dissolved electrolytic material than did the toxic water prepared by simple distillation, as was shown by conductivity measurements kindly made upon these waters by Dr. W. Fraenkel, but the total salt content of the charcoal-treated water was calculated to be less than 0.01 per cent, so that the removal of toxicity seems not to be related to an increase in salt content. Furthermore, similar decrease in the toxicity of the water was brought about by substances which were chemically very unlike the charcoal used in these distillations. The small amount of chalk that failed to produce improvement when added to ordinary distilled water was much in excess of the amount dissolved, so that the marked beneficial effect of a larger amount of chalk cannot be considered as due to the addition of calcium to the water. The improvement produced by colloidal platinum and

by agar jelly appears also to have been due to adsorptive action, though a discussion of this matter will not be given place here. It is interesting to remark that addition of sand, cotton, and filter paper failed to produce any correction of the ordinary distilled water of these experiments, although these substances have been found by Nägeli (20), Dandeno (7), True and Oglevee (36) and Jensen (9), to be active in improving other toxic solutions. The difference thus noted may be of course due either to a difference in the toxic substances dealt with or to differences in the solids used. Breazeale (5) obtained similar negative results upon adding quartz flour, filter paper, paraffin, or sand to solutions of H_2SO_4 which were toxic to corn seedlings. He suggested that the failure of these substances to reduce the toxicity of the solutions was due to the high concentration of H_2SO_4 necessary to produce toxic action, and the consequent relatively slight adsorption of the acid by the solids. This explanation can not, however, apply to the results described above, since in these experiments the amounts of the toxic substances were extremely small.

In considering the behavior of *Spirogyra* in different nutrient media (see p. 335), it has been observed that the optimum concentration of the solution appeared to be a function of the kind of water used. With solutions that contained salts in the proportions adopted by Molisch and Crone and were prepared with nontoxic water, the optimum concentration for the growth of *Spirogrya* was found to be from 0.05 to 0.1 per cent, while similar solutions prepared with ordinary distilled water exhibited an optimum concentration ten times as great. It thus appears that the toxicity of the ordinary distilled water was more or less overcome by the larger amount of nutrient salts present and that, conversely, the retarding effect of relatively high salt concentration was counterbalanced by the presence of the toxic material of the water. The influence of dissolved salts in overcoming the toxicity of solutions has been noted by other authors,* but the whole question here raised is not at present in a state to warrant an attempt at detailed discussion. It is obviously related to the general problem of physiological antagonism. Some points on salt antagonism will be brought forward in the succeeding section.

* Breazeale (4), Livingston *et al.* (11), Livingston (12), Sumner (35), Schreiner and Reed (28), and Schreiner and Skinner (32, 33).

The beneficial effect of the action of alga filaments, in rendering originally toxic water less toxic to other filaments of the same or another form (see p. 341–2), has been noted already. While the evidence at hand suggests the probability that this effect may be due to an absorptive (or adsorptive) action on the part of the filaments,—Nägeli (**20**), Deherain and Demoussy (**8**),—and that it may be therefore directly comparable with similar effects produced by other solids with very large surface exposure, it must be nevertheless remembered that such an effect may be also partially or wholly due to chemical alterations of the originally toxic substances, as if brought about by enzymatic or other material emanating from the plant. No evidence is available for a decision in this matter. The effects produced upon *Spirogyra* in toxic water, by sediment from the stock culture of this plant (III, 33) or from a *Nitella* culture (III, 32), together with the comparative growth of the alga in water from the two cultures just mentioned (III, 36, 37), may suggest a possible excretion from *Spirogyra* of material more harmful to itself than to *Nitella*. It appears that the question of toxic and antitoxic excretions may enter into problems of algal growth just as it has come to play so important a part in the physiology of the bacteria and fungi and, recently, in that of the higher plants.

III. SALTS

It has been frequently shown for both animals and plants that the toxicity of many solutions of single salts may be counteracted by the presence of other salts in the same solution, without regard to the physiological effect of the latter salts when employed singly.

Loew (**15, 16, 17, 18**) would restrict this conception of the antagonistic action of two ions to the single case of calcium and magnesium. Benecke (**1**) showed that the toxicity of other salts than those of magnesium is counteracted by calcium, but ascribed the antagonistic action to calcium only. Osterhout (**21, 22, 23, 24, 25**) has, however, observed antagonism between fourteen different pairs of ions, including potassium, sodium, ammonium, calcium, magnesium, strontium, and barium. Loeb (**13**) reported that the toxic effect of a pure NaCl solution, on the eggs of *Fundulus*, was partly counteracted by each of a number of salts, including

the bases: calcium, barium, magnesium, strontium, cobalt, aluminium, lead, zinc, and chromium.

The experimentation about to be reported, upon the relation to *Spirogyra* of the salt content of the medium, is merely qualitative, the aim being to gain some knowledge of a number of possible conditions in algal cultures rather than to investigate any of the chemical questions here encountered. No attention has been given to the chemical characteristics of the salts employed, the solutions having been prepared on the percentage basis, and the terminology of percentage will be retained in the discussions. The experiments are partly repetitions of those of Benecke (1). Aside from the effect of dissolved salts to counteract the toxicity of salt solutions, these experiments also include a number of tests bearing upon the influence of undissolved materials upon this same sort of toxicity.

Throughout these experiments no water was used which had not been shown to be nontoxic; it had all been distilled from animal charcoal in glass, condensed in glass, and collected in glass. Precautions were always taken to avoid possible contamination of the dishes used, especially in the case of the cultures without calcium. All salts used, except the $CaCO_3$, were those of Merck. The experiments are listed, with their results, in TABLE V.

For the study of the influence of calcium in the medium a calcium-free solution was prepared from equal portions by weight of KNO_3, K_2HPO_4, KCl, and $MgSO_4$. This solution was tested in two concentrations, 0.4 and 0.1 per cent (of total salt content by weight), and both proved highly injurious to the *Spirogyra* here employed (V, 1). The addition of calcium-free animal charcoal produced no improvement in either case (V, 2), but common wood charcoal, pulverized, which was shown by test to contain some calcium, improved the weaker solution (V, 3). In the weaker solution a small amount of $CaCl_2$ produced about as marked improvement as did wood charcoal (V, 4), a trace of $CaCO_3$ allowed still better growth (V, 5), while an abundance of the last-named, only slightly soluble salt kept the alga in excellent condition during the entire period of the experiment—35 days (V, 5). These same experiments, performed with solutions prepared from ordinary distilled water, gave the same results, except that the

solutions thus made were all more toxic than those from nontoxic water.

A solution similar to the one without calcium, but with magnesium also absent, was prepared with equal parts by weight of KNO_3, K_2HPO_4, and KCl. This was more toxic than the calcium-free solution with magnesium present; both 0.4 and 0.1 per cent concentrations were fatal to the plant within two days (V, 6). Animal charcoal produced no improvement in the stronger solution (V, 7). The addition of calcium carbonate in considerable excess of its solubility enabled the plant to grow for several days (V, 8). A solution containing 0.1 per cent of the three potassium salts and 0.1 per cent of $CaCl_2$ was fatal within three days (V, 9), while the addition of 0.1 per cent of $MgSO_4$ to the 0.3 per cent solution of potassium salts prolonged the life of the organism for six days, but did not completely counteract the toxicity (V, 10). The last is a repetition of the first experiment of this section, where the organism lived 28 days (V, 1).

A simple solution of magnesium sulphate was fatal to the plant in concentrations ranging from 0.4 to 0.01 per cent (V, 11). Animal charcoal produced improvement only in the weakest of these concentrations (V, 12). Wood charcoal (with some calcium present) slightly improved both the 0.1 and the 0.4 per cent solutions (V, 13). While the simple solution of $MgSO_4$ killed the organism in two or three days, a 0.4 or 0.1 per cent solution of $MgSO_4$ plus 0.1 per cent of $CaCl_2$ (V, 14), as well as 0.1 per cent solution of $MgSO_4$ plus 0.1 per cent of KCl (V, 15), allowed the alga to live fourteen days. In these experiments the addition of potassium was just as efficient in counteracting the toxicity of magnesium as was the addition of calcium.

To determine whether the effect of $CaCO_3$ in counteracting the toxicity of $MgSO_4$ is to be considered as due solely to the addition of calcium to the solution or partially to other causes, the following experiments were carried out. A saturated solution of $CaCO_3$ was prepared and to this was added 0.4 per cent of $MgSO_4$. At the same time, to a 0.4 per cent solution of $MgSO_4$ was added an excess of finely divided $CaCO_3$. In the former solution, the alga was markedly injured within nineteen hours, and was totally dead at the end of fourteen days (V, 16). In the solution contain-

ing solid $CaCO_3$, however, the alga remained in good condition for seven days and had many filaments apparently uninjured at the end of fifteen days, when the experiment was discontinued (V, 17). These and other lines of evidence obtained during the progress of this work seem to indicate that the beneficial effect of the powdered $CaCO_3$ was due in part to other causes than the mere addition of calcium to the solution, probably to its adsorptive action. This suggestion is further supported by the results of Livingston *et al.* (11) Snyder and Cook (34), Breazeale (5), and Schreiner and Reed (28).

The colloidal solution of platinum already referred to rendered a 0.01 per cent solution of $MgSO_4$ decidedly less toxic (V, 18), but the addition of 0.008 per cent $PtCl_4$ to a 0.01 per cent $MgSO_4$ solution produced no observable improvement.

Although, as was noted above, the addition of 0.1 per cent of KCl rendered a 0.1 per cent solution of $MgSO_4$ less toxic, a 0.1 per cent solution of KCl alone was decidedly more toxic than this mixture (V, 20), and a 0.4 per cent solution of KCl was fatal within two days (V, 19). This result is in agreement with the work of Osterhout (22). The colloidal solution of platinum produced improvement in a 0.1 per cent solution of KCl (V, 21). Addition of 0.1 per cent of $CaCl_2$ to a 0.1 per cent solution of KCl rendered the latter slightly less toxic (V, 22), although a 0.2 per cent solution of $CaCl_2$ was fatal within a few hours or days (V, 23).

Two experiments were made bearing upon the relative endurance, in solutions of the above salts, of samples of *Spirogyra* originally from the same source, but subjected for a time to different surroundings. One portion of an alga culture which had been growing vigorously for sixty-six days in 0.1 per cent Crone's solution was rinsed in nontoxic water and placed in a solution containing 0.1 per cent of KCl and 0.1 per cent of $CaCl_2$ (V, 24) and another portion of the same culture was likewise rinsed and placed in a 0.2 per cent solution of $CaCl_2$ (V, 25). On the following day were added to both of these cultures samples of *Spirogyra* from the stock jar. In both cases the solution was injurious to both samples of the alga, but decidedly less so to the filaments from Crone's solution than to those from the stock culture (V, 22, 23). This result again emphasizes the well-known fact, already men-

tioned, that the internal conditions or the physiological state of organisms used in experimentation of this sort must always be taken into account.

In this portion of the work, no evidence was obtained for a specific action of the calcium salts in antagonizing other salts. The action of $CaCl_2$ in antagonizing $MgSO_4$ and KCl was no more pronounced than was that of KCl in counteracting the toxicity of $MgSO_4$ and of $CaCl_2$, and that of $MgSO_4$ in counteracting the toxicity of KCl and of $CaCl_2$. These results seem strongly to support the conception of Loeb (**14**) and Osterhout (**22, 25**) of the importance of physiologically balanced solutions. $MgSO_4$, $CaCl_2$, and KCl, when used separately, and a mixture of three potassium salts were all extremely toxic in the present investigation, but when the salts of any two of these bases were brought together (as in combinations of $MgSO_4$ and $CaCl_2$, $MgSO_4$ and KCL, KCl and $CaCl_2$) the resulting solution was much less toxic. A mixture of the three potassium salts here employed was as toxic as KCl alone and only when salts of all three metals were present in favorable proportions was good growth obtained. Results similar to these were reported by Bokorny (**2**). As it has been shown by several workers that *Spirogyra* requires calcium, these facts cannot be interpreted by supposing that this alga differs from higher plants in being able to survive in the absence of this element.

The improvement produced in the weaker toxic salt solutions by animal charcoal may be considered as probably due to the adsorptive action of the finely divided carbon. The beneficial effect of the addition of colloidal platinum to toxic solutions may have been likewise due to its adsorption of the toxic salts.

The author is gratefully indebted to Prof. B. E. Livingston for helpful suggestions in the preparation of this paper.

SUMMARY

1. Cultures of *Spirogyra longata* (Vauch.) Kg. were kept under laboratory conditions in a vigorous state during the entire period of the experiments,—more than 60 days. Crone's solution was the best of the nutrient solutions tested, and that of Molisch was almost as satisfactory, but the solution of Sachs seemed slightly

less favorable, while that of Knop was distinctly unfavorable, probably because of its marked acidity.

2. Both the tap water and the ordinary distilled water of the Heidelberg Institut were markedly toxic to this *Spirogyra*, even after distillation (or redistillation) from glass to glass.

3. The toxicity of the tap water was partially removed by concentrating the water to a fraction of its original volume, and was entirely removed by heating to 144° C. or by distillation in glass from animal charcoal; but the water was not greatly improved by simple distillation or by heating to 100° C. The toxicity of ordinary distilled water was partly or wholly corrected by the presence in the culture of chalk, lime, solid agar, dry sphagnum moss, colloidal platinum, or of other adsorbents; it was partially corrected by redistillation or by heating to 144° C. The presence in the cultures of filter paper, cotton, sand, kaolin, or $CaCl_2$ was without effect, and redistillation in glass from animal charcoal did not produce nontoxic water.

4. The results obtained seem to indicate that the toxic materials present in the tap water were mostly volatile (perhaps organic substances derived from the soil), with a relatively small amount of nonvolatile material probably emanating from the supply pipes. The toxic substances in the ordinary distilled water were mostly nonvolatile (probably derived from the supply pipes and from the still), with a small amount of volatile matter carried from retort to receiver with the distillate.

5. When nontoxic water was used, the best growth was obtained in nutrient solutions containing from 0.05 to 0.1 per cent of total salts; but when ordinary distilled water was used, the optimum concentration of similar nutrient solutions was ten times as great.

6. With KNO_3, K_2HPO_4, KCl, $MgSO_4$, and $CaCl_2$ (singly or in various combinations), a mixture of the three potassium salts was as toxic as KCl alone; KCl, $MgSO_4$, and $CaCl_2$ were all extremely toxic when used singly; but mixtures of any two of these three were less toxic than the solution of a single one. Good growth was obtained only when salts of all three metals were present in favorable proportions. The toxicity of $MgSO_4$ appeared to be as completely counteracted by KCl as by $CaCl_2$.

7. Weak solutions of certain toxic salts were improved by the addition of calcium-free animal charcoal or colloidal platinum. It seems indicated that the effect of powdered $CaCO_3$, in counteracting toxicity due to nutrient salts, was due in part to the adsorptive action of the solid.

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TABLE I

CULTURES OF SPIROGYRA IN NUTRIENT MEDIA PREPARED WITH DISTILLED WATER

No. of culture	Nature of culture medium			Duration of cultures, *days*	Condition of plants *
	Author and concentration, *per cent of total salts in medium*	Kind of distilled water used in medium	Agar added to medium, *per cent by weight*		
1	Sachs, 0.05	ordinary	—	3	*D*
2	0.05	nontoxic	—	48	*E*
3	0.10	ordinary	—	10, 20	*Pd, Pd*
4	0.10	do.	1.0	34	*P*
5	0.10	nontoxic	—	40, 18, 44	*E, Eg, Gp*
6	0.50	ordinary	—	3,14	*D, D*
7	0.50	do.	1.0	60	*E*
8	0.50	nontoxic	—	50	*G*
9	1.00	ordinary	—	2	*D*
10	1.00	nontoxic	—	44	*P*
11	Knop, 0.05	ordinary	—	3, 3	*D, D*
12	0.05	nontoxic	—	48	*Gp*
13	0.10	ordinary	—	3	*D*
14	0.10	do.	1.0	49	*Pd*
15	0.10	nontoxic	—	18, 31, 44, 11	*G,† Pd, Pd, Pd*
16	0.50	ordinary	—	18, 49, 1	*G,† P, D*
17	0.50	nontoxic	—	23, 2	*Pd, D*
18	1.00	ordinary	—	9	*Pd*
19	1.00	nontoxic	—	1	*D*
20	Molisch, 0.05	ordinary	—	3	*D*
21	0.05	nontoxic	—	48	*E*
22	0.10	ordinary	—	7	*Pd*
23	0.10	do.	1.0	49	*P*
24	0.10	nontoxic	—	62, 62, 40, 40	*E, G, G, G*
25	0.50	ordinary	—	55, 48, 22, 14	*G, P, P, Pd*
26	0.50	do.	1.0	66	*E*
27	0.50	nontoxic	—	50	*Eg*
28	1.00	ordinary	—	46	*P*
29	1.00	nontoxic	—	51	*P*
30	Crone, 0.05	ordinary	—	3	*D*
31	0.05	nontoxic	—	48	*E*
32	0.10	ordinary	—	3	*D*
33	0.10	do.	1.0	18	*Pd*
34	0.10	nontoxic	—	23, 40, 40, 51	*E, E, E, G*
35	0.50	ordinary	—	48, 13, 14	*Eg,† Pd, Pd*
36	0.50	do.	1.0	60	*E*
37	0.50	nontoxic	—	50	*P*
38	1.00	ordinary	—	82	*G*
39	1.00	nontoxic	—	51	*Gp*

* The condition of the plants is indicated as follows: *E*, excellent, *G*, good; *P*, poor; *D*, dead. A combination of letters denotes a condition between that denoted by each of these letters—as, *Eg* indicates a condition between excellent and good, etc. Where the experiment was repeated, each of the several notations given refers to a single experiment. The numbers in the preceding column (duration in days) refer to the experiments in the same order as do the letters; thus, the first letter denoting *condition* and the first number denoting *duration* both refer to the same experiment, etc.

† The amount of medium used was unusually small, in comparison with the number of filaments in the culture.

TABLE II

CULTURES OF SPIROGYRA IN TAP WATER, WITH TREATMENTS AND ADDITIONS

No. of culture	Treatments of, and additions to, tap water	Duration of cultures, *days*	Condition of plants*
1	Untreated	54, 4, 1	*P, D, D*
2	Distillate from glass to glass	12, 24, 2	*P, Pd, D*
3	As 2, first portion	3, 2	*P, D*
3*a*	As 2, middle portion	3, 12	*Gp, Gp*
3*b*	As 2, final portion	12, 3	*P, D*
4	Boiled to 1/10 orig. vol.	15, 12	*Eg, P*
5	Evaporated to 1/7 orig. vol.	1	*G*
5*a*	Untreated (control to 5)	1	*P*
6	Evaporated to 1/6 orig. vol.	1	*Gp*
6*a*	Untreated (control to 6)	1	*Pd*
7	Evaporated to 1/3 orig. vol.	1	*D*
7*a*	Untreated (control to 7)	1	*D*
8	15 mins. at 144° C.	37	*E*
8*a*	Untreated (control to 8)	37	*Pd*
9	45 mins. at 100° C.	46	*Pd*
10	Distillate from animal charcoal, glass to glass	1 to 44	*E, E, E, E, Eg, Eg, Eg, Eg, G, P*
11	Boiled with animal charcoal to 1/8 orig. vol., filtered	26	*Eg*
11*a*	Distillate from 11	26	*E*
11*b*	Do., charcoal from 11 added to culture.	26	*Gp*
12	As 11, filtered	16	*G*
12*a*	As 11, not filtered	16	*Gp*
12*b*	As 11*a*	16	*G*
12*c*	As 11*b*	16	*Gp*
13	Untreated plants from stock jar†	6	*G*
14	As 13, but plants from Crone's sol.†	6	*E*

* The condition of the plants is indicated as follows: *E*, excellent; *G*, good; *P*, poor; *D*, dead. A combination of letters denotes a condition between that denoted by each of these letters, as: *Eg* indicates a condition between excellent and good, etc. Where the experiment was repeated, each of the several notations given refers to a single experiment. The numbers in the preceding column (duration in days) refer to the experiments in the same order as do the letters; thus, the first letter denoting *condition* and the first number denoting *duration* both refer to the same experiment, etc.

† Nos. 13 and 14 were simultaneous, in the same dish.

TABLE III

CULTURES OF SPIROGYRA IN ORDINARY DISTILLED WATER, WITH TREATMENTS AND ADDITIONS

No. of culture	Treatments	Additions	Duration of cultures, *days*	Condition of plants*
1	Untreated	—	54, 9, 6, 1	*Gp, D, D, D*
2	Distillate, glass to glass	—	8	*G*
2*a*	Boiled, concentrated, residue from 2	—	1	*D*
3	Distillate, glass to glass, to 1/8 orig. vol., first portion	—	1	*D*
3*a*	As 3, middle portion	—	4	*Eg*
3*b*	As 3, final portion	—	4	*G*
3*c*	Boiled, contentrated to 1/8 orig. vol., residue from 3	—	1	*D*
4	Distillate, glass to glass, to 1/9 orig. vol., first portion	—	9	*G*
4*a*	As 4, middle portion	—	9	*P*
4*b*	As 4, final portion	—	9	*P*
4*c*	As 4, all portions mixed	—	9	*P*
4*d*	Distillate, glass to glass	Salts to form 0.5 *p.c.* Crone's sol.	9	*D*
4*e*	Boiled, concentrated, residue from 4*b*	—	9	*D*
4*f*	As 4*e*	Salts to form 0.5 *p.c.* Crone's sol.	1	*D*
5	Distillate, glass to glass, to 1/16 orig. vol., 1st portion	—	12	*Eg*
5*a*	As 5, middle portion	—	12	*Pd*
5*b*	As 5, final portion	—	12	*D*
5*c*	As 5, all portions mixed	—	12	*P*
5*d*	Distillate, glass to glass	Salts to form 0.5 *p.c.* Crone's sol.	12	*Gp*
5*e*	Boiled, concentrated, residue from 5*b*	—	12	*P*
5*f*	As 5*e*	Salts to form 0.5 *p.c.* Crone's sol.	1	*D*
6	Distillate, glass to glass, first portion	—	4	*Pd*
7	Distillate from animal charcoal, glass to glass	—	46	*E*
8	As 7, to 1/8 orig. vol., first portion	—	2, 12	*D, D*
8*a*	As 8, middle portion	—	3, 12	*G, Pd*
8*b*	As 8, final portion	—	12, 1	*P, D*
8*c*	Boiled with animal charcoal, filtered, concentrated residue from 8*b*	—	3, 12	*P, P*
9	Boiled 3 mins.	—	1	*D*
10	Boiled with animal charcoal, not filtered	—	1	*D*
11	15 mins. at 144° C.	—	39	*G*
12	Untreated	Nontoxic water to double vol.	2, 1, 1	*D, D, D*
13	*do.*	*Nitella* water to double vol.	1	*D*

TABLE III, *continued.*

No. of culture	Treatments	Additions	Duration of cultures, *days*	Condition of plants*
14	*do.*	Colloidal Pt sol. to double vol.	26	*Gp*
15	*do.*	Filter paper	10, 1	*Pd, D*
16	*do.*	Cotton	1, 2	*D, D*
17	*do.*	Kaolin	1, 1	*D, D*
18	*do.*	Quartz sand	1, 1	*D, D*
19	*do.*	Chalk, trace	2	*D*
20	*do.*	*do.*, excess	5	*D*
21	*do.*	*do.*, abundance	23, 56	*E, Eg*
22	Shaken with chalk, decanted after 3 hours	—	4	*D*
22*a*	As 22, decanted after 10 days	—	9, 10	*G, Pd*
23	Shaken with wood charcoal, decanted	—	53	*P*
23*a*	As 23, decanted after 4 days	—	39	*G*
24	Shaken with soil, decanted after several days	—	44	*Gp*
25	Untreated	Lime, abundance	2	*E*
26	*do.*	$CaCl_2$, O 0.4 *p.c.*	3	*D*
27	*do.*	Agar sticks	20	*E*
28	*do.*	Agar, not hardening	1	*D*
29	*do.*	Agar, 1 *p.c.*, alga on surf.	54	*G*
30	*do.*	Agar, 2 *p.c.*, as 29	3	*D*
31	*do.*	Sphagnum moss	23, 23, 9	*E, E, Pd*
32	*do.*	*Nitella* sediment	48	*Gp*
33	*do.*	*Spirogyra* sediment	5	*D*
34	*do.*		1	*D*
34*a*	Water from 34, alga removed	Alga replaced by fresh material from stock jar	1	*D*
34*b*	Water from 34*a*, alga removed	*do.*	2	*D*
34*c*	Water from 34*b*, alga removed	*do.*	15	*P*
34*d*	Water from 34*c*, alga removed	*do.*	44	*E*
35	Treated with *Ulothrix*,† removed after 28 days	*do.*	22	*P*
35*a*	Untreated (control to 35)	—	1	*D*
36	Water from stock *Spirogyra* culture	—	52, 47, 9, 4	*E, Eg, G, Gp*
37	Water from *Nitella* culture	—	52, 9	*E, E*

* The condition of the plants is indicated as follows: *E*, excellent; *G*, good; *P*, poor; *D*, dead. A combination of letters denotes a condition between that denoted by each of these letters—as, *Eg* indicates a condition between excellent and good, etc. Where the experiment was repeated, each of the several notations given refers to a single experiment. The numbers in the preceding column (duration in days) refer to the experiments in the same order as do the letters; thus, the first letter denoting *condition* and the first number denoting *duration* both refer to the same experiment, etc.

† *Ulothrix* killed except in center of mass.

TABLE IV

EFFECT OF VARIOUS TREATMENTS OF TAP AND DISTILLED WATER UPON THEIR TOXICITY

Treatment	Tap Water	Ordinary Distilled Water
Distilled in glass (distillate)	−	−+
Distilled in glass (undistilled residue)	+	−
Distilled with carbon (distillate)	+	−+
Distilled with carbon (undistilled residue)	+	−
Heated to 144° C.	+	+*

* Still toxic, but much improved.

TABLE V

CULTURES OF SPIROGYRA IN SALT SOLUTIONS PREPARED FROM NONTOXIC WATER, WITH AND WITHOUT ADDITIONS

No. of culture	Salts in solution, per cent				Additions	Duration of culture, days	Condition of plants*
	KNO_3	K_2HPO_4	$MgSO_4$	KCl			
1†	0.1	0.1	0.1	0.1	—	13, 28, 8	*Gp, Gp, Pd*
1*a*	0.025	0.025	0.025	0.025	—	26, 29	*Gp, P*
2	0.1	0.1	0.1	0.1	Animal charcoal‡	11	*Pd*
2*a*	0.025	0.025	0.025	0.025	*do.*	26	*Gp*
3	0.1	0.1	0.1	0.1	Wood charcoal¶	15	*Pd*
3*a*	0.025	0.025	0.025	0.025	*do.*	35	*G*
4	*do.*	*do.*	*do.*	*do.*	$CaCl_2$	28	*G*
5	*do.*	*do.*	*do.*	*do.*	$CaCO_3$, trace	35	*Eg*
5*a*	*do.*	*do.*	*do.*	*do.*	$CaCO_3$ abundance	35	*E*
6	0.133	0.133	—	0.133	—	2	*D*
6*a*	0.033	0.033	—	0.033	—	2	*D*
7	0.133	0.133	—	0.133	Animal charcoal‡	3	*D*
8	*do.*	*do.*	—	*do.*	$CaCO_3$	6	*P*
9	0.1	0.1	—	0.1	$CaCl_2$ 0.1 *p.c.*	3	*D*
10	*do.*	*do.*	0.1	*do.*	—	6	*Pd*
11	—	—	0.4	—	—	3, 2	*D, D*
11*a*	—	—	0.1	—	—	3, 2	*D, D*
11*b*	—	—	0.05	—	—	2	*D*
11*c*	—	—	0.01	—	—	6, 2	*Pd, D*
12	—	—	0.4	—	Animal charcoal‡	2	*D*
12*a*	—	—	0.1	—	*do.*	2	*D*
12*b*	—	—	0.05	—	*do.*	2	*D*
12*c*	—	—	0.01	—	*do.*	9, 5	*P, P*
13	—	—	0.4	—	Wood charcoal¶	15	*P*
13*a*	—	—	0.1	—	*do.*	6	*Pd*
14	—	—	0.4	—	$CaCl_2$ 0.1 *p.c.*	15	*P*
14*a*	—	—	0.1	—	*do.*	14	*Pd*
15	—	—	*do.*	0.1‖	—	14	*P*
16	—	—	0.4	—	$CaCO_3$ to saturation	14	*Pd*
17	—	—	*do.*	—	$CaCO_3$, in excess	15	*Gp*
18	—	—	0.01	—	Colloid. sol. Pt 90 *p.c.*	19	*Gp*
18*a*	—	—	*do.*	—	$PtCl_4$ 0.008 *p.c.*	2	*D*
19	—	—	—	0.4	—	2	*D*
20	—	—	—	0.1	—	6	*Pd*
21	—	—	—	*do.*	Colloid. sol. Pt	12	*P*
22	—	—	—	*do.*	$CaCl_2$ 0.1 *p.c.*	7, 6	*Gp*,° *Pd*
23	—	—	—	—	$CaCl_2$ 0.2 *p.c.*	7, 1	*D*,△ *D*
24	—	—	—	0.1	$CaCl_2$ 0.1 *p.c.*	7	*G*°
25	—	—	—	—	$CaCl_2$ 0.2 *p.c.*	7	*G*△

* The condition of the plants is indicated as follows: *E*, excellent; *G*, good; *P*, poor; *D*, dead. A combination of letters denotes a condition between that denoted by each of these letters—as, *Eg* indicates a condition between excellent and good, etc. Where the experiment was repeated, each of the several notations given refers to a single experiment. The numbers in the preceding column (duration in days) refer to the experiments in the same order as do the letters, thus, the first letter denoting *condition* and the first number denoting *duration* both refer to the same experiment, etc.

† Culture 23 days old showed no calcium with acetic acid and ammonium oxalate.

‡ A culture 14 days old showed no calcium.

¶ Containing some calcium.

‖ Showed no calcium.

° *Spirogyra* from culture in Crone's solution, 66 days old, was used in 24 and 25. The first test of the stock material (22) and of material from Crone's solution (24) were simultaneously carried out in the same dish.

△ The second test of the stock *Spirogyra* (23) and of material from Crone's solution (25) were simultaneously carried out in the same dish.

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The production of a promycelium by the aecidiospores of Caeoma nitens Burrill

Otto Kunkel

Introduction

Except in the genus *Endophyllum*, so far as known, the aecidiospores of the rusts give rise to sporophytic mycelium. Its sporophytic nature is shown by the fact that each cell contains two nuclei that have been produced by successive conjugate divisions of the two nuclei in the aecidiospore. The aecidiospores of some of the species of *Endophyllum*, however, produce a promycelium. Its cells are uninucleate and belong, therefore, to the gametophytic generation. This fact has been well established through the work of Tulasne (**10**), Sappin-Trouffy (**8**), Maire (**5**) and others. Hoffmann has shown that nuclear fusion occurs in the aecidiospores and that this fusion nucleus divides to form the nuclei of the sporidia. This interesting form has received considerable attention in recent years, because its life history offers suggestions regarding evolution in the rusts.

While engaged in a study of the effects of media on the germination of various spores I was surprised to find that the aecidiospores of *Caeoma nitens* taken from leaves of *Rubus frondosus* Bigel. on germination produce a promycelium in much the same way as do the aecidiospores of *Endophyllum Sempervivi* Lév. My first suspicion that this might be due to the influence of the medium upon which the spores had been placed proved groundless, for further tests showed that they germinate in exactly the same way when placed in distilled water or in tap water. The production of a promycelium by these aecidiospores seems to have escaped the observation of the numerous students of this common and widely distributed rust.

Galloway (**6**) figured them germinating in water and shows that the germ tube becomes more or less septate. He did not, however, observe the production of sporidia

and his drawings hardly suggest the promycelial nature of the germ tube. Clinton (1) has also studied the germination of these spores and gives more than twenty figures, showing them in various stages of development, but he failed to find any trace of sporidia. He mentions having observed the spores in water cultures during two or three days and gives a detailed account of their germination. He also observed the germination of the spores on the moist surface of young blackberry leaves.

Olive (7) and Kurssanow (4) have investigated *Caeoma nitens* from the cytological standpoint. They have shown that sexual fusions occur in the base of the caeoma and that the aecidiospores typically contain two nuclei.

OBSERVATIONS

The aecidiospores used in this study of their germination were obtained from well infected leaves of *Rubus frondosus*. The leaves were collected in three different parts of Van Cortlandt Park, New York City. All of the spores germinated in the same fashion.

The cultures were made in Petri dishes containing distilled water, tap water, and agar media of various kinds. The spores were simply dusted over the surface of the medium and generally gave a high per cent of germination. The cultures were kept at room temperature (about 23° C.).

The promycelium ordinarily consists of five cells (FIG. 1, *a*), four of which bear sporidia. Stained preparations show that the stalk cell is without a nucleus and that the other four cells contain one nucleus each (FIG. 1, *b*), thus demonstrating the promycelial nature of the germ tube. Frequently the promycelium consists of only four cells and in that case each cell is capable of producing a sporidium (FIG. 1, *c*). There are also instances where the promycelium consists of less than four cells, but in such cases two or more sporidia are generally produced on the same cell. The promycelium sometimes consists of more than five cells (FIG. 1, *d*). Five or six sporidia are sometimes produced by the same promycelium, but this is a very rare case. In FIG. 1, *e* is shown a basidium with sporidia in different stages of development; it also shows one sporidium that has fallen off from its sterigma and has begun to germinate.

The sterigma arises as a pointed outgrowth from a promycelial cell. It tapers evenly and is generally slightly curved rather than straight. Its diameter at the base varies between three and five microns, while at the tip its diameter measures from one and one half to two and one half microns. It normally reaches a length of from fifteen to twenty microns, but in some cases it becomes much longer.

The sporidium, as is the rule in the rusts, is a typically kidney-shaped spore, slightly narrower at its basal than at its distal end. Maturing in a short time after the aecidiospore begins to germinate, it soon falls off from its sterigma and, on a moist surface, germinates

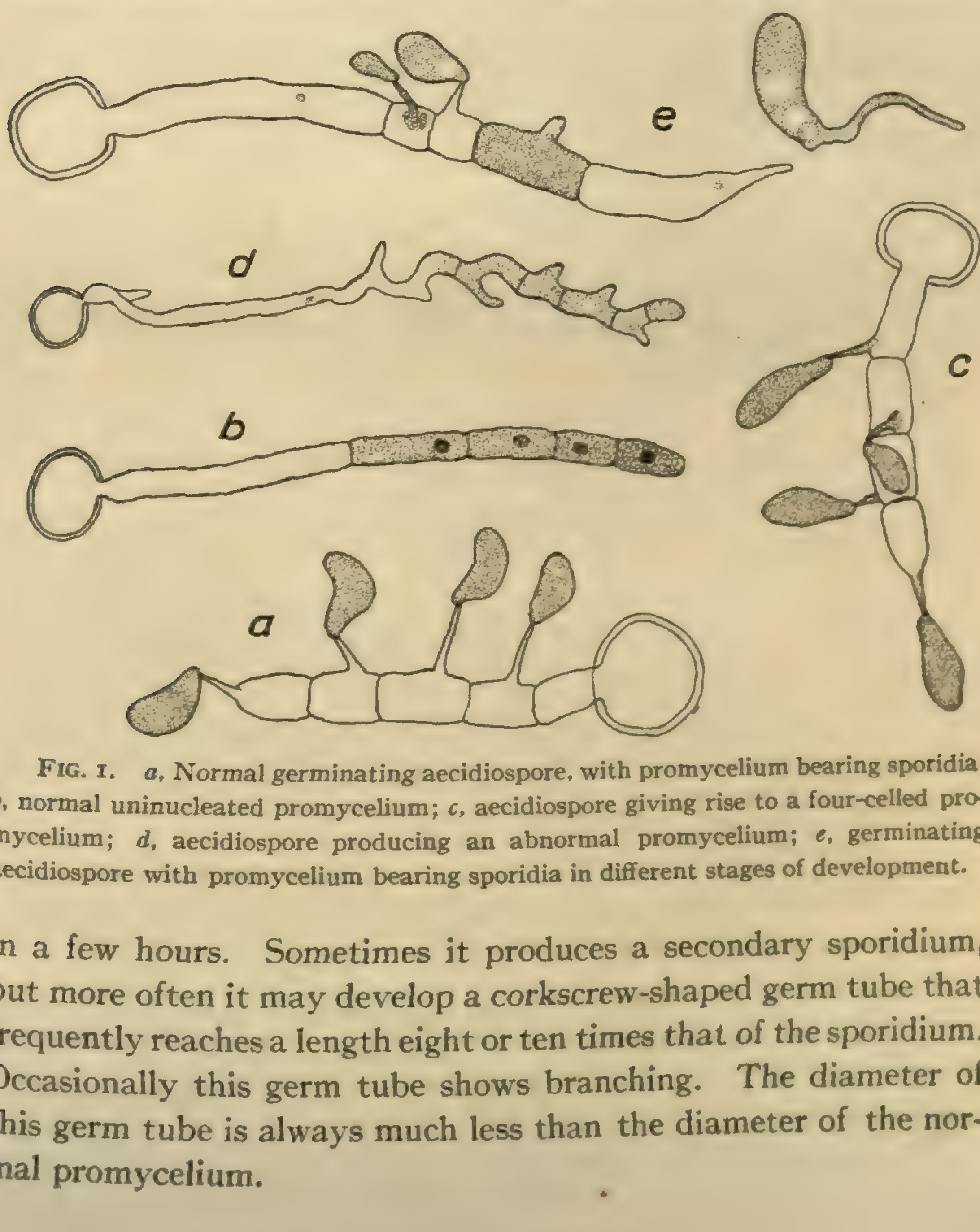

FIG. 1. *a*, Normal germinating aecidiospore, with promycelium bearing sporidia; *b*, normal uninucleated promycelium; *c*, aecidiospore giving rise to a four-celled promycelium; *d*, aecidiospore producing an abnormal promycelium; *e*, germinating aecidiospore with promycelium bearing sporidia in different stages of development.

in a few hours. Sometimes it produces a secondary sporidium, but more often it may develop a corkscrew-shaped germ tube that frequently reaches a length eight or ten times that of the sporidium. Occasionally this germ tube shows branching. The diameter of this germ tube is always much less than the diameter of the normal promycelium.

Although there is considerable variation in the length and shape of the promycelium when grown on various media, under fairly similar conditions it is rather constant both in size and in shape. Generally it reaches a length of three or four times the diameter of the spore, but sometimes it becomes much longer than this. The average diameter of the spore, based on a measurement of twenty-five spores taken at random, is twenty-one microns. The average length of the mature promycelium, based on the same number of measurements, is seventy-eight microns.

DISCUSSION

Tranzschel (9) and Clinton (2) both claim to have established by infection experiments that *Puccinia Peckiana* Howe is the teleutostage of *Caeoma nitens*. Tranzschel removed three healthy blackberry plants from the park of the St. Petersburg Forestry Institute. One of these plants he grew under a bell jar in the laboratory of the Institute; the other two plants were placed in a garden. The three plants were inoculated with spores of *Caeoma nitens*. Later in the season all of the three plants became infected with *Puccinia Peckiana*. Tranzschel had no control plants in his experiment and he makes no mention of having observed the plants in the park of the St. Petersburg Forestry Institute at the time his plants showed infection with the *Puccinia*.

Clinton transplanted blackberry plants from the forest to his greenhouse. He inoculated two of these with the aecidiospores of *Caeoma nitens* taken from infected blackberry plants. In a little less than two months both of these plants showed infection with *Puccinia Peckiana*, while several other blackberry plants that had been used as checks showed no infection. It is worth noting that three raspberry plants which he inoculated with spores of *Caeoma nitens* taken from infected raspberry plants, failed to become infected. All plants used had been free from both the *Caeoma* and the *Puccinia* during the previous summer.

It is hardly to be expected that the change from sporophyte to gametophyte should occur in two different places in the life history of the same rust, but further experiments are needed in order to settle this point.

The production of a promycelium by the aecidiospores of

Caeoma nitens suggests that it is a short-cycled rust in no way connected with *Puccinia Peckiana* and in its life history quite comparable to *Endophyllum Sempervivi*. The perennial mycelium lives over winter in the tissues of the host. Cell fusions at the base of the chains of aecidiospores produce sporophytic cells from which the aecidiospores arise by conjugate division of the two cells that fuse. This gives binucleated aecidiospores and intercalary cells. The fact that the aecidiospores germinate in a promycelium suggests that here, as in *Endophyllum*, nuclear fusion takes place in the aecidiospore and we may expect that the sporidia produced by the promycelium reinfect the host and produce a mycelium with uninucleated cells, thus completing the life cycle.

If, on the other hand, *Puccinia Peckiana* is a stage in the life history of this fungus, the problem is not so simple and no similar case is known among the rusts.

As was pointed out in the introduction, the fact that sexual fusions occur previous to the production of aecidiospores is well established. The above described germination of these spores makes clear another stage in the life history of this fungus, and raises a number of interesting questions regarding its position among the rusts. I shall test during the coming summer the evidence regarding the connection supposed to exist between *Caeoma nitens* and *Puccinia Peckiana*, and shall also undertake a cytological study of both of these forms. The wide distribution and economic importance of *Caeoma nitens*, its abundant production of spores and the ease with which they may be germinated and studied makes it a favorable object for class use. It is, therefore, highly important that all stages in its life history should be thoroughly understood.

SUMMARY

1. The aecidiospores of *Caeoma nitens* on germination regularly produce a promycelium.

2. This promycelium normally consists of five cells. The stalk cell contains no nucleus, but the other four cells contain one nucleus each.

3. Each uninucleated cell bears a sporidium on a sterigma.

4. These sporidia germinate immediately by producing either a secondary sporidium or a germ tube.

5. The production of a promycelium by these aecidiospores suggests that *Caeoma nitens* is a short-cycled rust and casts doubt on the connection supposed to exist between this fungus and *Puccinia Peckiana.*

6. *Caeoma nitens* is the only rust of the caeoma type, having aecidiospores that are known to produce a promycelium. The other rusts having aecidiospores that are known to function as teleutospores, belong to the one genus *Endophyllum.*

I am greatly indebted to Dr. R. A. Harper and Dr. W. G. Marquette for advice and criticism while engaged in this work.

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A case of bud-variation in Pelargonium

A. B. Stout

(WITH PLATE 20)

The precise nature of bud-variation is not satisfactorily known. No adequate classification of the various kinds of bud-variation has been made. Recent investigations regarding the nature of plant chimeras indicate that some of the phenomena generally considered as bud-variation are associated with chimeras and are to be explained by the nature of the chimeras. Observations and experiments are now being made at the New York Botanical Garden on various types of bud-variation. In the studies on *Pelargonium* one case has arisen which seems of special interest in its bearing on the nature of bud-sports from plants that are chimeras.

Baur (1909 *a* and *b*; 1911) has recently shown that the variegation in the case of the "albomarginatae" varieties of *Pelargonium zonale* is due to the presence of white and green cells which are sharply distinct and which occupy a characteristic position in relation to each other. It has been long known that the paler tissue of these variegated plants owes its characteristics to a lack of chlorophyl in its cells. Baur shows that the plastids are present in the white cells but are colorless.

Baur further claims that this arrangement of green and white cells in the leaf can be explained by the arrangement of the corresponding tissues in the growing point and actually shows that in the plants whose leaves have layers of white cells on the exterior there is in the apex of the stem a cap of white cells over the greener cells beneath. In such plants the relative position of the white and the green cells is maintained throughout the development of the leaves.

By further study Baur (1909 *a*; 1911) found that in other cases these two kinds of cells may be variously arranged with reference to each other. In some plants various stems and leaves show a

sectoral arrangement with a more or less bilateral distribution of the two kinds of cells. In certain types of *Pelargonium* the green cells are outside as one or two layers covering the white cells. In some individuals streaks of one of the tissues are mingled with the other.

Baur is able to interpret the conditions in these various forms by using the conception developed by Winkler (1907) in his remarkable discoveries regarding the so-called chimera-nature of graft hybrids. Baur introduced the term *periclinal chimera* for the condition where the peripheral cell-layers are different from the enclosed tissues and *sectoral chimera* for the cases where there is more or less of a bilateral or radial distribution. The term *hyperchimera*, first suggested by Strasburger (1909), is used for the cases where there is a more or less intimate mixture of the different kinds of cells.

On these various chimeras of *Pelargonium*, wholly green or wholly white shoots may arise. This is due to the fact that the two kinds of cells which are maintained by the cell divisions in the meristematic regions become segregated in the growing points, the process not being essentially different from that by which peripheral, sectoral, or hyperchimeras arise.

The various types of these *Pelargonium* chimeras are familiar to horticulturists and have been propagated rather widely by cuttings, thus preserving quite uniformly the different forms. The periclinal chimeras having white peripheral cell layers are commonly cultivated forms on account of the striking effect of the white-margined leaves.

One of these varieties is known by the trade name of *Madame Salleroi*. During the summer of 1912 a plant of this type which was grown in an outdoor bed at the propagating houses of the New York Botanical Garden produced a branch in which the relative position of the two kinds of cells is reversed. When the cutting was made during the early part of the summer it possessed only leaves with the white margin. In October of that year, when first brought to the attention of the writer, the plant appeared as shown in the photograph here reproduced (see PLATE 20). Two branches, one the main and the other a lateral branch, bore leaves with the white cell layers placed externally to the green as

was the case in the plant from which the cutting was made. The leaves were quite uniform in shape and in coloration and are quite typical for the variety known as *Madame Salleroi*. Dr. L. H. Bailey kindly made the varietal determination from leaves taken from these branches and further states in a letter to the writer that this variety has not been thus far placed specifically. As shown in PLATE 20, the enclosed green cells fail to develop uniformly toward the margin of the leaves, thereby leaving an irregular marginal zone of pure white cells. In the central portion of these leaves the enclosed green tissues show through the white.

On the third branch, which is a lateral one, the leaves are quite different. They are larger and the surface is green to the extreme margin. These leaves are not, however, of a uniform green, for through the central portion of each there is an irregular palmate-shaped area of lighter green which is due to white cell-layers enclosed between the upper and the lower green layers. In other words the place relationship of the white and the green cells is here reversed from what it is in the main part of the plant. In this branch the plant has literally turned itself inside out. Microscopical examination of free-hand sections confirmed the superficial observations as to the color relations.

In the black and white plate accompanying this article the general pattern in the leaves is well shown by the different shades. Since this plant has been under observation, about twenty leaves have matured on this branch. As shown in PLATE 20 the amount and distribution of the white tissue varies in the different leaves. In some leaves there are small flecks of white scattered through the green. A few of the leaves when about half developed show traces of a dark zonal band which is a feature of various showy-leaved Pelargoniums. When these leaves are mature, however, this zonal band is faint.

Baur notes a case of bud-variation identical with this one. He states (1909 *a*, p. 333), that the plant which he designated as Pel. 9 had white-bordered leaves but produced in 1908 a branch having wholly green leaves but which were plainly of a yellowish green in the center. The anatomical studies of these leaves (1909 *a*, p. 345) showed that the white cells were enclosed by the green cells.

In the light of Baur's anatomical studies this sort of bud-variation is readily understood as due to a mechanical readjustment of the two kinds of cells already in the growing points. This particular type involves more extensive rearrangement than the cases where pure green or pure white branches are produced by the development of a bud containing only one kind of cells to the exclusion of the other. For the development of a branch reversing the position of the two kinds of cells as described above there must be a breaking out of the enclosed green cells in the growing point and a growth of both green and white cells in such a manner that the green cells surround the white cells. It may be that in this case the green cells break forth at two separate points not far distant and that in further growth they meet, enclosing the white cells.

On the main portion of the plant here shown, the mature leaves possess over their whole surfaces two peripheral cell-layers that are white. To maintain this relationship the cell divisions which give rise to these layers must occur only in planes which are at right angles to the surface of the leaf. The outer layers do not contribute to the vascular tissues and the inner green tissue does not form epidermis, a fact clearly shown by Baur. In the sporting branch, however, the green cells get to the surface and form the epidermis as well as some of the mesophyl and vascular tissue, while the white cells cease to form epidermis and now contribute only to the inner tissues. The cells preserve the green and white character of their chromatophores but take on different structures or different functions according to position and environment.

In his interesting report of results of anatomical and hereditary studies of variegated varieties of *Pelargonium*, Baur was not especially concerned with the evidence of interaction between the two kinds of cells, the white and the green, where both exist in the same leaf. His photographs, however, show the same sort of difference which have appeared so strikingly in the case here under consideration.

The marked differences between the two kinds of leaves produced on this plant (PLATE 20) make it clear that the outer layers largely determine the size of the leaves and the depth of the lobing. When the green is outside the leaf is larger, more deeply lobed and

like those which are borne on the branches that are composed purely of green tissue. When the white is outside, the leaf is much smaller and more like those leaves which are composed only of white tissue. Several plants of *Pelargonium Madame Salleroi* of the same clone as the plant producing this bud-variation have been under observation in the propagating houses. Several of these have produced leaves composed wholly of white cells. These have been of practically the same shape and size as the variegated leaves on the same plant. The pure white cells are, of course, dependent upon the green cells for carbohydrate food. In the case of a chimera relationship with the green cells enclosed, there may be mechanical and chemical stimuli to the overlying white cells that result in a slightly larger leaf. This effect is, however, not marked.

All the potentialities of a large and deeply lobed leaf are present in the green cells of a typical leaf of the *Madame Salleroi* variety. When these green cells get to the exterior those potentialities find expression, but as long as the peripheral layers of white are uniformly maintained, there is no visible evidence that these potentialities exist. Their suppression may be due chiefly to mechanical limitations imposed by the peripheral layers of white cells which decrease the number of cell divisions.

In the various plant chimeras there is an association of more or less independent and different kinds of cells. In the chimeras resulting from grafting, the two kinds of cells may be decidedly different, producing, when separate, two distinct types of leaves, but when associated together, forming leaves of still different patterns. The various chimeras produced by Winkler (1907 and 1909) and the chimera *Crataegomespilus Asnieresii* (see illustration by Baur 1911, *pl. VIII*) illustrate this phenomenon. In addition to such mechanical and physical interactions, Winkler (1910) has presented some evidence that there may be a vegetative fusion of cells in graft tissues producing what he would consider as the only true graft-hybrid, and he further holds that hybrid modifications may also result from the migration of such substances as atropin or nicotine between stock and scion.

These facts indicate that the general phenomena of plant chimeras have a very direct bearing on theories of morphogenesis

and that cellular interaction is a potent factor in influencing cell differentiation and in determining the physical characteristics of such organs as leaves.

The bud-sports which arise from the various *Pelargonium* chimeras are, we may say, rather simple cases of variation due to a mechanical rearrangement of the kinds of cells already present. Their appearance is a confirmation of the rule that like produces like in its application to cell lineage rather than evidence of spontaneous somatic mutation or variation. In this case the real variation occurs when the white cells appear as the progeny of green cells. The frequency of this spontaneous variation in *Pelargonium* (and in other cases as well) and the real nature and the causes of the process are problems for future solution.

NEW YORK BOTANICAL GARDEN.

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(1911–1913)

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Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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STOUT: BUD-VARIATION IN PELARGONIUM

Vol. 40 No. 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1913

A botanical cross-section of northern Mississippi, with notes on the influence of soil on vegetation

ROLAND M. HARPER

(WITH PLATES 21, 22)

INTRODUCTION

The coastal plain of the southeastern United States seems to be more diversified geographically in Mississippi than in any other state, with the possible exception of Florida; and the correlations between geology and vegetation are more obvious there than in any other part of the coastal plain, unless it is in western Alabama. These interesting correlations were graphically described by Dr. E. W. Hilgard in his epoch-making "Geology and Agriculture of Mississippi" in 1860, in the fifth volume of the Tenth Census reports in 1884, and in his text-book on Soils* in 1906. On pages 490–492 of the book last named there is a special phytogeographical sketch of the northern end of the state, between latitudes 34° and 35°, accompanied by an outline map showing the soil provinces or geographical divisions, and a table giving in very condensed form the chemical and physical characters of the soil and a list of a few of the more characteristic trees in each region.

In the summer of 1911 I had occasion to cross the northern half of Mississippi twice, first a little south of the portion last mapped by Dr. Hilgard, and then almost through the center of it. In so doing I crossed all but two or three of the divisions on his map (which form belts approximately parallel to the Mississippi

* Reviewed in Torreya 7: 170–175. 1907.

[The BULLETIN for July (40: 305–376. *pl. 20*) was issued 18 Jl 1913.]

River, instead of to the coast as in most other parts of the coastal plain, and therefore running north and south), and I took advantage of the opportunity to make a more complete analysis of the vegetation of each division than had been attempted in that part of the country before. The observations made on that trip, besides embodying some previously unrecorded facts, have led to some conclusions which seem sufficiently new to be offered to the botanical public.

Previous literature. Besides the works of Dr. Hilgard already noted, and a few papers on particular regions, which will be mentioned farther on, the following have an important bearing on the phytogeographical problems of northern Mississippi.

Campbell & Ruffner. A physical survey extending from Atlanta, Ga., across Alabama and Mississippi to the Mississippi River, along the line of the Georgia Pacific Railway, embracing the geology, topography, minerals, soils, climate, forests, and agricultural and manufacturing resources of the country. 8vo. 147 pp. and 2 folded maps. New York, 1883. (Pages 92–96 and 102–107 relate to Mississippi.)

A. B. Hurt. Mississippi: its climate, soil, productions, and agricultural capabilities. U. S. Dept. Agric. Misc. Spec. Rep. no. 3. 89 pp. 1883?. (Contains an annotated list of trees, among other things.)

Sargent & Mohr. (Forests of) Mississippi. U. S. Tenth Census 9: 530–536, and colored map. 1884.

W. J. McGee. The Lafayette formation (in Mississippi). U. S. Geol. Surv. Ann. Rep. **12**[1]: 451–461. 1892.

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A. F. Crider. Geology and mineral resources of Mississippi. U. S. Geol. Surv. Bull. 283. 99 pp. 1906.

Crider & Johnson. Summary of the underground-water resources of Mississippi. U. S. Geol. Surv. Water Supply & Irrigation Paper 159. 86 pp. 6 plates (including colored geological map), 11 text-figs. 1906.

A. F. Crider. A provisional [*sic*] geologic and topographic map of Mississippi. 20 × 28 in., colored. First published in 1907, and issued in connection with several different bulletins of the Mississippi State Geological Survey.

C. E. Dunston (of the [U. S.] Forest Service). Preliminary examination of the forest conditions of Mississippi. Mississippi State Geol. Surv. Bull. 7. 76 pp. (Not dated, but apparently published two or three years ago).

Some of these publications are more useful to botanists than their titles would seem to indicate. There are very few references to the area under consideration in purely botanical literature, doubtless chiefly because nearly all the plants growing there, as far as known, are widely distributed, as I have already pointed out in the case of northwestern Alabama and the Delaware peninsula,* and can be studied more conveniently elsewhere.

Itinerary. On June 6, 1911, I crossed the eastern boundary of Mississippi at McCrary, in Lowndes County, and continued to Columbus, Artesia and West Point by the Mobile & Ohio R.R. In the next few days I traveled almost due westward from West Point, in about latitude 33° 30′, on the "Southern Railway in Mississippi" (formerly Georgia Pacific Ry.), stopping at Carrollton, Greenwood, Itta Bena, Stoneville and Greenville, and making short excursions on foot from each of these places. On the 10th I crossed the Mississippi River at Greenville by going ten or twelve miles upstream to Luna Landing, Arkansas (the nearest railroad point on the other side), which gave me a view of the banks of the river for that distance. On the 16th I re-entered Mississippi near Mineral Wells, in DeSoto County, traveled southeastward on the Frisco System (formerly Kansas City, Memphis and Birmingham Ry.) to Tupelo, then southward on the Mobile & Ohio to West Point and Artesia, and back to Alabama the same way as before. Over a year later, namely, on August 31, 1912, I came into the state near Corinth, in Alcorn County, traveling southward on the Mobile & Ohio R.R. to Tupelo, West Point, etc. The notes made on this last trip have been combined with those of 1911 in making up the list of plants for one of the regions, as will be explained presently.

Method of treatment. The various soil belts described by Dr. Hilgard are not as easily recognized now as they were when he knew them best, for the increase of population and cultivated fields generally tends to obliterate geographical distinctions. And

* Torreya 7: 44–45. 1907; 9: 217. 1909.

as I crossed the boundaries of most of the regions at the rate of 25 to 40 miles an hour, and without ever having seen them before, I was unable to discern some of the distinctions that have been made by those who have explored the territory on foot and made careful studies of the stratigraphy. In the following pages the results of my superficial study of the more conspicuous vegetation of these belts, as far as I could recognize them, are set forth. Notwithstanding its superficiality, this has one advantage over previous studies of Mississippi vegetation in being quantitative.

Under each belt or region named the geology and topography are briefly described, and the percentages of lime, potash, and phosphoric acid in the soil, taken from Hilgard's report on cotton production in the fifth volume of the Tenth Census, are indicated in nearly every case, for purposes of comparison. Additional literature is cited for some of the regions. All those crossed east of Carrollton and Holly Springs extend southeastward into Alabama, where they have been recently described, with quantitative analyses of the forests of each, in my geographical report on the economic botany of that state (Geol. Surv. Alabama, Monograph 8. 228 pp. June, 1913).

The plants identified in each belt are divided first into trees, shrubs and herbs, and then arranged in order of abundance or frequency, with a number indicating how many times each was seen, except in the case of belts so narrow that the frequency numbers would be too small to have much significance. Species seen not more than once in a distance of fifty miles are usually omitted. The names of evergreens are printed in heavy type and those of vines in italics.

THE REGIONS IN DETAIL

From the Alabama line to about three miles west of Columbus, a distance of about 12 miles, the country is underlaid by the Eutaw formation, one of the divisions of the Cretaceous, but the surface is mostly a sandy loam of much more recent age, presumably the Lafayette.* As the railroad in this short distance crosses the Buttahatchee and Tombigbee Rivers and traverses a few

* A description of this part of Mississippi by Dr. Hilgard can be found in the 5th volume of the Tenth Census, pages 296–298.

miles of the bottoms of the latter, the vegetation visible from the train is mostly that of river-bottoms. And as the soil is so fertile that most of it is under cultivation by this time, there is not much natural vegetation left. Most of the shrubs and herbs seen were introduced species, and it is hardly worth while to enumerate them. The commonest trees seem to be *Pinus Taeda*, *Salix nigra*, *Liquidambar*, *Taxodium distichum*, *Quercus Phellos* and *Ulmus alata*, in the order named.

Cretaceous prairie region. From McIntyre (three miles west of Columbus) to Artesia and West Point, thence westward about to the line between Clay and Webster Counties, the country is characterized by a newer Cretaceous formation, the Selma Chalk or Rotten Limestone, with little or no Lafayette loam over it. On the return trip I entered the same belt near the northeastern corner of Pontotoc County, and traversed it lengthwise from Tupelo to Artesia. This is the "northeastern prairie region" of Hilgard's Mississippi reports, a direct continuation of the central prairie region or black belt of Alabama, which has been well described by Smith,* Mohr,† and several less familiar writers.

This prairie region is gently undulating or "rolling," with very few springs or small streams. Its soil, mostly a gray calcareous clay, was once considered the most fertile in the state, with the possible exception of that in the "delta" (described farther on), and consequently most of it has been long given over to agriculture. Analyses of this soil published by Dr. Hilgard show 0.99–1.37% of lime (CaO), 0.33–0.86% of potash (K_2O), and 0.03–0.27% of "phosphoric acid" (P_2O_5). With the possible exception of corn, cotton always has been the principal crop (about 20% of the total

* Tenth Census **6**: 55–58, 68, 128–140 (pages numbered correctly at bottom). 1884; Geol. of Coastal Plain of Ala. 281–285, 350–352, 533–535, 538–539, 576–577, 585, 605–608. 1894.

† Plant Life of Alabama 97–106. 1901. (This however includes two adjoining belts which were not separated by Dr. Mohr.)

The Mississippi portion of the black belt has been described by Hilgard, Hurt (op. cit., 10–12), and Crider (U. S. G. S. Bull. 283: 17–19), and in the government soil surveys of Monroe, Clay, Lowndes, Oktibbeha and Noxubee Counties. Report no. 96 of the U. S. Department of Agriculture, by H. H. Bennett of the Bureau of Soils, and M. A. Crosby of the Bureau of Plant Industry, on the soils of the prairie regions of Alabama and Mississippi and their use for alfalfa, published late in 1911, contains some interesting descriptions and illustrations of the present condition of the region in both states.

area having been devoted to that crop as long ago as 1880), but in recent years, especially since the approach of the boll-weevil, a great deal of alfalfa has been raised. A large amount of land also is now devoted to pasturage, as in many other parts of the world where agriculture has been long established.

In such a fertile region forests, especially primeval forests, are of course scarce. Some parts of it indeed are said to have been treeless when first discovered, whence the name "prairie"; but it would be hardly possible to determine the location and extent of the original prairie spots with any degree of satisfaction now. However, this is one of the few parts of the South where one can see fields and pastures on the sky-line in many places instead of all woods. The remaining forests are principally of two kinds: oak groves on broad low knolls of poorer soil (Lafayette?), and bottom-land forests near some of the creeks and rivers. The latter doubtless owe their preservation to the fact that the earlier settlers found such land too difficult to drain, and often too insalubrious to live in; but the growing population continually requires more land, and the bottom-land trees are gradually disappearing before the axe of the farmer. Pines are not seen at all in this part of Mississippi, except an occasional solitary specimen of *Pinus Taeda* or *P. echinata*, presumably introduced.

Although very different geologically, and not very similar in climate, there are some striking resemblances between the present appearance of this region and the prairie region of Illinois. Both have comparatively level topography and fertile grayish to blackish clay soil, and streams which fluctuate considerably and are muddy most of the time. Both have very little woodland at the present time (they were much less alike in this respect before the country was settled, though), and almost no evergreens. Luxuriant corn-fields make up a large part of the summer landscape (in Illinois the crop is nearly all corn, but in Mississippi it is about half cotton), and finally in both regions the population is about as dense as extensive agriculture alone will support, and consequently it is practically at a standstill outside of the manufacturing cities.

Just as in the Cretaceous region of New Jersey and Delaware,* the herbaceous flora recognizable from a train consists mostly of

* See Bull. Torrey Club **37**: 425. 1910; Torreya **12**: 221. 1921.

weeds; but even the weeds are rather characteristic of this region, both in Mississippi and in Alabama. The following list of plants is derived from 128 miles of travel through the prairie region in 1911, and from 69 miles over part of the same route (viz., from Tupelo to Artesia and McIntyre) in 1912. The country between Corinth and Tupelo, traversed on the 1912 trip, although mostly underlaid by the same formation, is not taken into consideration in the statistics because it has much more of the superficial sandy loam (Lafayette?), a difference which is strongly reflected in the vegetation. The figures for the two years are kept separate, because one set of observations was made in early summer and one in late summer, which makes a considerable difference in the aspect of the herbaceous vegetation. The first figure in each case is for June, 1911, and the second for August, 1912. Species seen less than three times in traveling these 197 miles are omitted.

TREES

24+7 Quercus stellata
21+5 Salix nigra
15+10 Populus deltoides
18+3 Liquidambar Styraciflua
15+5 Quercus Phellos
13+5 Quercus falcata?
8+3 Quercus marylandica
7+3 Platanus occidentalis
6+4 Hicoria ovata?
7+0 Ulmus alata?
5+2 Celtis sp.
4+2 Quercus nigra
3+3 Quercus pagodaefolia
6+0 Gleditscha triacanthos (introduced?)
5+0 Toxylon pomiferum (introduced)
5+0 Quercus alba
5+0 Hicoria alba?
4+2 Quercus lyrata?
3+0 Fraxinus sp.
3+0 Morus rubra
2+1 Cercis Canadensis
1+2 **Juniperus virginiana**

SHRUBS

19+4 **Prunus angustifolia**
13+1 **Sambucus canadensis**
4+5 Cephalanthus occidentalis
7+1 *Brunnichia cirrhosa*
6+0 *Tecoma radicans*
3+2 Rhus glabra
2+2 Sassafras variifolium
3+0 *Smilax glauca*
3+0 Rubus sp.
2+1 **Arundinaria macrosperma**

HERBS

31+18 Sorghum Halepense
37+6 Melilotus alba
18+18 Tripsacum dactyloides
5+21 Ambrosia trifida
24+0 Anthemis Cotula
8+15 Helenium tenuifolium
20+0 Daucus pusillus
0+19 Ambrosia bidentata
19+0 Plantago aristata
10+4 Acuan illinoense
1+9 Chaetochloa sp.
6+4 Ambrosia artemisiaefolia
0+9 Eupatorium serotinum
0+8 Paspalum sp.
8+0 Apocynum cannabinum
0+7 Chamaecrista fasciculata
6+0 Monarda citriodora
6+0 Ratibida pinnata
4+2 Silphium laciniatum
0+6 Vernonia sp.
5+0 Cicuta Curtissii
0+5 Syntherisma sanguinalis
0+5 Bidens sp.
0+5 Xanthium sp.
5+0 Lepidium virginicum
4+0 Boltonia asteroides
4+0 Asclepias tuberosa
4+0 Rumex sp.
2+2 Typha latifolia
0+4 Solidago sp.
0+4 Croton capitatus
0+4 Carduus sp.
3+0 Andropogon scoparius
3+0 Cyperus pseudovegetus
0+3 Conoclinium coelestinum
0+3 Silphium terebinthinaceum
0+3 Gaura Michauxii
0+3 Sporobolus indicus

Assuming the above figures to represent correctly the relative abundance of the species, less than 2% of the woody plants (i. e., individuals, not species) are evergreen. The significance of this fact will be discussed farther on.

The oaks in this region, as in the "delta" region to be described below, are rather puzzling, especially to one who has never seen them before and has no opportunity to stop and examine them closely in the light of descriptions or specimens. Dr. Hilgard* has described some curious forms of oaks in this very region, which ought to be investigated by a competent taxonomist. The comparatively large number of herbs, and the occurrence of a few genuine prairie species, such as *Ambrosia bidentata*, *Silphium laciniatum*, *S. terebinthinaceum*, *S. perfoliatum*, *Mesadenia tuberosa*, and *Polytaenia Nuttallii* (the last three seen only once, and therefore not listed), are reminders of the prairie conditions that once existed in this region.

Pontotoc Ridge. The next younger formation in Mississippi is the Ripley, the uppermost division of the Cretaceous. Its strata are more sandy and therefore less easily eroded and dissolved than the Rotten Limestone, and they give rise to a belt of hills, rather rugged for the coastal plain, known in Mississippi as the Pontotoc Ridge. According to Dr. Hilgard's analyses its soil contains 0.17–0.28% of lime, 0.15–0.37% of potash, and 0.08–0.11% of phosphoric acid; or approximately half as much of these important materials as in the prairie belt.† The Ripley formation and its corresponding topography are wanting in the latitude of Columbus and Greenville, but on the return trip I traversed it for about 15 miles, between New Albany and Sherman.

Although the soil of the Pontotoc Ridge is perceptibly less fertile than that of the neighboring prairies, it is mostly under cultivation now, and one does not get a very accurate idea of its native vegetation by merely crossing it once on a fast train. In the following list the numbers are omitted, because they would be too small to have much significance.

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* Soils 491, 494, 498–502.

† For descriptions of this part of Mississippi see Hilgard, Geol. & Agric. Miss. 83–92. 1860; U. S. Tenth Census 5: 221–223, 292–294. 1884; and the U. S. soil survey of Pontotoc County by Bennett and Winston, 1907.

TREES	SHRUBS
Salix nigra	Sambucus canadensis
Liquidambar Styraciflua	Robinia Pseudacacia
Cornus florida	Prunus angustifolia
Pinus echinata	Sassafras variifolium
Platanus occidentalis	Rhus glabra
Quercus alba	
Quercus falcata	**HERBS**
Cercis canadensis	Asclepias tuberosa
Liriodendron Tulipifera	Tripsacum dactyloides
Populus deltoides	Cicuta Curtissii
Quercus marylandica	Sorghum Halepense
Quercus stellata	(and several less frequent weeds)

A noteworthy difference between this list and the one next preceding is the presence of *Pinus echinata** and *Liriodendron*, species which do not grow in the richest soils. I am not sure that any of the shrubs and herbs listed could have been found in prehistoric times in the places where I saw them.

Post-oak flatwoods. The oldest Eocene formation in Mississippi underlies the "post-oak flatwoods," which lie immediately west of the Pontotoc Ridge in Union County and of the prairie region in Clay County, and extend southeastward into Alabama. This belt is nowhere more than 15 miles wide, and where I crossed it on the westward trip its boundaries seemed so ill-defined, that I could not very well separate my notes on it from those on adjacent regions. On the way back, however, I had little trouble in locating its western edge near Hickory Flat, and its eastern edge at the western base of the Pontotoc Ridge, near New Albany.

The Lafayette formation seems to be absent in the flatwoods, and the Eocene strata have weathered into a very stiff clay, containing, according to Dr. Hilgard's analyses, 0.08–0.18% of lime, 0.25–0.75% of potash, 0–0.05% of phosphoric acid, and 0.17–0.85% of magnesia. Both its physical and its chemical properties make this soil ill adapted to agriculture, and the region is very thinly settled. This part of Mississippi has been described by Hilgard,† Hurt,‡ and E. J. Hill,§ and in the government soil surveys of Pontotoc, Clay and Oktibbeha Counties.

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* Prof. Sargent's map of the pine forests of Mississippi (opposite page 530 of the 9th volume of the Tenth Census) does not indicate the occurrence of any pine at all in this region.

† Geol. & Agric. Miss. 273–288; Tenth Census 5: 224–227, 294–296.

‡ Op. cit., 12–14.

§ Torreya 6: 231–232. 1906. In this interesting paper, based on observations made in Oktibbeha County in 1858, the post-oak flatwoods west of Starkville are

Hickory Flat and New Albany are only 14 miles apart, and between those points I had less than twenty minutes in which to gather the following list of plants.

TREES	HERBS
Pinus echinata	Sorghum Halepense
Quercus stellata	Helenium tenuifolium
Liquidambar Styraciflua	Typha latifolia
Salix nigra	Erigeron ramosus
Fagus grandifolia	Tripsacum dactyloides
Quercus Phellos	Rudbeckia hirta
Quercus marylandica	Scirpus Eriophorum
Quercus falcata	

SHRUBS

Sambucus canadensis
Rhus glabra
Arundinaria sp.
Cephalanthus occidentalis
Tecoma radicans

This list is too short to draw many important conclusions from, but the fact that a pine stands at the head is significant. The second tree, *Quercus stellata*, is the one which gives the region its name. Forests of very similar aspect can be seen in the "barrens" of extreme northern Alabama and in the Paleozoic flatwoods of the Coosa valley in Georgia and Alabama.

Eocene red hills. The more hilly portions of the Eocene (i. e., excluding the flatwoods) are traversed by the Southern Railway from the eastern part of Webster (formerly Sumner) County to Carrollton, and by the "Frisco" from the Mississippi River to Hickory Flat. Geologists subdivide the Eocene into several formations, but with the exceptions named above and below, I was not able to correlate these with any marked differences in topography or vegetation. The Southern Railway keeps pretty close to a small river nearly all the way across Webster County, and that probably makes more difference in the appearance of the country between that county and those immediately west of it than the difference in age of the underlying rocks does. West of a line drawn from about Holly Springs to Carrollton, though, the Eocene is covered by a superficial formation which affects the vegetation enough to warrant a geographical separation.

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called pine-barrens, evidently on account of the contrast with the pineless prairie region bordering them on the east. (The "*Aletris obovata*" mentioned, judging from the description given, and a specimen which I have since seen in the author's herbarium, seems to have been wrongly identified. The locality is several hundred miles from any known station for that species, and in a very different kind of country.)

The typical Eocene country of northern Mississippi is moderately hilly, with reddish to yellowish clayey soil, some of it derived from the weathering of the Eocene strata, and some belonging to the much more recent Lafayette. According to Dr. Hilgard's analyses these soils contain 0.05–0.09% of lime, 0.09–0.24% of potash, and 0.02–0.09% of phosphoric acid; which is a smaller percentage of the first two than in any other region here described. Like most other parts of northern Mississippi, it is now mostly under cultivation, and primeval forests are scarce. The same belt extends northward into Tennessee and eastward to South Carolina, if not farther.*

The following plants were noted more than once in Webster and Montgomery Counties and the eastern half of Carroll on June 7th, or between Holly Springs and Hickory Flat on the 16th; a total distance of 77 miles.

TREES

32 **Pinus echinata**
21 Liquidambar Styraciflua
21 Salix nigra
9 Taxodium distichum
7 Liriodendron Tulipifera
7 Quercus Phellos
7 Quercus falcata
6 **Pinus Taeda**
6 Quercus marylandica
5 Quercus alba
5 Cornus florida
4 Quercus nigra
3 Carpinus caroliniana
3 Fagus grandifolia
3 Platanus occidentalis
2 Quercus stellata
2 Ulmus alata
2 Quercus Michauxii
2 Populus deltoides
2 Cercis canadensis
2 Castanea dentata

SHRUBS

18 Sambucus canadensis
13 Prunus angustifolia
5 *Brunnichia cirrhosa*
5 Rhus glabra
3 Alnus rugosa
3 Rhus copallina
2 Rubus sp.
2 Cephalanthus occidentalis
2 Robinia Pseudacacia

HERBS

15 Plantago aristata
11 Rubdeckia hirta
8 Anthemis Cotula
7 Physostegia sp.
7 Erigeron ramosus
5 Daucus pusillus
4 Sitilias caroliniana
4 Saururus cernuus
4 Cicuta Curtissii
3 Sorghum Halepense
3 Helenium tenuifolium
3 Cyperus pseudovegetus
3 Asclepias tuberosa
3 Boltonia asteroides
3 Juncus aristulatus
2 Tripsacum dactyloides
2 Eryngium yuccaefolium
2 Koellia flexuosa
2 Rhexia lanceolata?
2 Typha latifolia
2 Ambrosia artemisiaefolia
2 **Juncus effusus**
2 Panicum scoparium
2 Cracca virginiana

* For descriptions of this part of Mississippi see Hilgard, Tenth Census 5: 231–235, 301–302; and the U. S. soil survey of Montgomery County. For notes on the South Carolina end of the same belt see Bull. Torrey Club 37: 411. 1910; 38: 225. 1911.

The pines are probably relatively more abundant now than they were originally, on account of their tendency to spread in old fields, so that the apparent proportion of evergreens among the woody plants (19 per cent) may be too large. But it is very evident that the soil of this region is better adapted to evergreens than is that of most of the other regions discussed in this paper. Ericaceae seem to be entirely absent, and native monocotyledons are not conspicuous. (There is no telling how many of the shrubs and herbs listed are really indigenous here, but probably not more than half.) Of the species enumerated, *Taxodium* and *Brunnichia* are almost confined to the coastal plain, and *Quercus Michauxii* and *Populus deltoides* mainly so as far as the southeastern states are concerned; but the other species are pretty widely distributed.

Yellow loam region. Between Memphis and Holly Springs the topography is much the same as in the region just described, but the surface is covered with a few to several feet of loess, a buff-colored very fine-grained somewhat calcareous silt,* which makes the vegetation considerably different. This is the "yellow loam region" or "brown loam table-lands" of Hilgard, which has no counterpart anywhere to the eastward. Dr. Hilgard's analyses show in this soil 0.24–0.25% of lime, 0.30–0.55% of potash, 0.07% of phosphoric acid, and 0.31–0.48% of magnesia.

Almost every acre of it, except on the immediate banks of streams, has been cultivated at some time or other, and much of it is now badly gullied. No primeval forests were seen, and no shrubs or herbs other than weeds, but probably nearly all the trees listed below grew in the same region in prehistoric times, even if not in exactly the same places where they are now. The following list covers 44 miles, about 12 of which were in Tennessee, but so close to the Mississippi line as not to cause any appreciable error.

	TREES		
12	Salix nigra	3	Liquidambar Styraciflua
7	Quercus falcata	2	Platanus occidentalis
5	Quercus marylandica	2	Gleditschia triacanthos
4	Quercus stellata	2	Diospyros virginiana
		2	Quercus alba

* For descriptions of this soil see the works of Hilgard and McGee mentioned near the beginning of this paper, also Hilgard, Am. Jour. Sci. **91**: 319–321. 1866; T. O. Mabry, Jour. Geol. **6**: 273–302. 1897.

TREES (continued)

1 Quercus nigra
1 Quercus Michauxii
1 Taxodium distichum
1 Quercus velutina
1 Liriodendron Tulipifera

SHRUBS

12 Prunus angustifolia
11 Sambucus canadensis
3 *Tecoma radicans*
3 Sassafras variifolium
3 Robinia Pseudacacia
1 Rhus glabra

HERBS

5 Plantago aristata
3 Rubdeckia hirta
2 Sorghum Halepense
2 Asclepias tuberosa
1 Tripsacum dactyloides
1 Daucus pusillus
1 Euphorbia sp.

Quercus nigra is partly evergreen (probably less so here than nearer the coast, though), but with this possible exception no evergreens were seen. Ericaceae and Cyperaceae are likewise rare or absent.

Bluff region. Carrollton is near the brow of a line of bluffs which border the flood-plain of the Mississippi River all the way from Memphis to Vicksburg, and form one of the most prominent topographic features in Mississippi. From Carrollton station (North Carrollton P. O.) the railroad descends rapidly for six or eight miles to the foot of the bluffs, following the valley of a creek. I walked the railroad from North Carrollton to Malmaison, which is near the edge of the flood-plain, and from there northward up into the bluff hills about two miles and back.

Geologists generally map the surface formation of these bluffs ("cane hills," they are called farther south) as loess, but what I saw of it in Carroll County looked almost exactly like the "second bottom" loam along many rivers in the coastal plain of Alabama, and quite different from the more typical loess which I saw a few days later in Arkansas, and between Memphis and Holly Springs. The steeper slopes of the bluffs are strewn in many places with subangular cherty pebbles.

The plants seen along and near the railroad and creek between Carrollton and Malmaison are mostly species characteristic of bottom-lands, as follows.

Taxodium distichum
Liquidambar Styraciflua
Salix nigra
Platanus occidentalis
Cercis canadensis
Carpinus caroliniana
Betula nigra
Morus rubra

TREES

Quercus Michauxii
Acer Negundo
Quercus lyrata
Juglans nigra
Liriodendron Tulipifera
Populus deltoides
Ulmus spp.

SHRUBS

Sambucus canadensis
Cephalanthus occidentalis
Brunnichia cirrhosa
Arundinaria macrosperma
Hydrangea quercifolia
Ampelopsis cordata
Rhus glabra
Hydrangea arborescens
Rosa carolina
Itea virginica

HERBS

Cicuta Curtissii
Saururus cernuus
Juncus effusus
Commelina hirtella
Carex triangularis?
Homalocenchrus oryzoides
Onoclea sensibilis
Carex lupulina?
Spirodela polyrrhiza
Panicum scoparium
Teucrium sp.
Diodia teres*
Euphorbia corollata
etc.

Up on the hills north of Malmaison the vegetation is much like that of ordinary dry woods at moderate altitudes throughout the South, as the following list shows.

TREES

Pinus echinata
Quercus marylandica
Cornus florida
Quercus falcata
Quercus stellata
Quercus alba
Hicoria alba
Quercus coccinea

SHRUBS

Ceanothus americanus
Hydrangea quercifolia

HERBS

Cracca virginiana
Pteridium aquilinum
Meibomia laevigata
Meibomia Michauxii
Koellia flexuosa
Psoralea pedunculata
Antennaria plantaginifolia
Polystichum acrostichoides
Mitchella repens
Dioscorea villosa

Judging from the vegetation, the soil of these hills must be considerably less fertile than that of the same line of bluffs farther south, as described by Dr. Hilgard (who apparently never visited Carrollton and vicinity). *Pinus echinata*, the commonest tree, does not seem to have been reported from this part of Mississippi at all before. It seems never to grow on loess (according to Call, Geol. Surv. Arkansas **1889**[2]: 184. 1891), or in any other very rich soil. This and several other species in the list can stand frequent forest fires, but *Hydrangea* and the three evergreen herbs and two vines grow mostly in ravines, where they are pretty well protected from fire.

The "Delta" (PLATE 21). Next is the "Yazoo delta" or Mississippi bottom. Many of its features can be matched fairly well in

* On sand-bars along the creek between Carrollton and North Carrollton. This species grows in quite a variety of habitats, mostly unnatural, but they all have at least one character in common: exemption from fire.

the flood-plains of smaller rivers, but they are here exhibited on a far larger scale than anywhere farther east. On the Mississippi side the "delta" extends from a few miles north of the northern boundary of the state down to Vicksburg, nearly three degrees of latitude, or 200 miles in a straight line, and has its maximum width of 60 miles about midway, or just in the latitude where I crossed it. Generally speaking, it is a vast plain, sloping gently southward, at a rate of about a foot to the mile, traversed by numerous crooked, sluggish, muddy rivers and bayous, whose banks are usually a little higher than the interstream areas. The larger rivers of the delta, such as the Yazoo and Sunflower, are thirty or forty feet deeper at high water than at low water, have a perceptible current, and are navigable for steamboats most of the year, while the smaller bayous are stagnant much of the time, and fluctuate comparatively little. At least 90% of the area is or has been subject to occasional inundation from the spring floods of the Mississippi River ("Father of Waters"), but the building of levees along the banks of the great river, in the last half century or so, has considerably restricted the overflows.

The soil is mainly a fine gray silt, coarsest on the banks of the larger streams, where the current in times of flood is swiftest. Analyses published by E. A. Smith and E. W. Hilgard show that it contains 0.26–1.35% of lime, 0.30–1.10% of potash, and 0.11–0.30% of phosphoric acid. This is one of the most fertile soils known, according to Dr. Hilgard (Soils, 116, 345), and very little commercial fertilizer has been used on it as yet. Most of the area seems to be under cultivation now (cotton being the principal crop), but there is still considerable primeval forest with splendid hardwood timber.*

There is much valuable information about this region in Humphreys and Abbot's voluminous government report on the physics and hydraulics of the Mississippi River, 1861 (reprinted with additions in 1876). Other references are: E. A. Smith, Proc. A. A. A. S. **20**: 251–262. 1872; C. G. Forshey, Proc. A. A. A. S. **21**: 78–111. 1873; Hilgard, Tenth Census **5**: 85–88, 241–247, 319–321. 1884; Campbell & Ruffner, op. cit. 93–96, 105–107;

* I saw only the middle of the delta, but from all accounts the northern half seems to be most extensively cultivated, and forests consequently more prevalent in the southern half.

Hurt, op. cit. 19–24. The latest paper on the area under consideration is Bulletin 244 of the Office of Experiment Stations, United States Dept. Agriculture, a "Report on the Belzoni* drainage district in Washington County, Mississippi," by H. A. Kipp, 1912. This comprises 55 pages, a map and several diagrams; and from the list of bench marks occupying the last six pages one can get a crude idea of the trees of the region and their relative abundance.

Running north and south near the middle of the "delta" is a narrow low ridge, described by Smith and Hilgard as the "dogwood ridge," and said to be above the reach of all floods. Where I crossed it, about Itta Bena, this ridge seems to be only a few inches high, and it would be hardly noticed by any one not making a special search for it. Even the inhabitants of that neighborhood who were interviewed on the subject seemed never to have heard of it. (It is doubtless more noticeable farther north.) I walked along or near the ridge from Sheppardtown to Itta Bena, eight miles, but the vegetation along there did not seem different enough from that of the rest of the region to be listed separately.

The following plants were seen more than once on June 7th to 9th, inclusive, from the train between Malmaison and Greenville, and on side trips on foot from Itta Bena, Elizabeth and Stoneville, a distance of about 75 miles in all.

TREES

31 Taxodium distichum
26 Liquidambar Styraciflua
25 Salix nigra
18 Gleditschia triacanthos
17 Populus deltoides
12 Ulmus alata?†
11 Quercus pagodaefolia
10 Quercus Phellos
7 Nyssa uniflora
6 Diospyros virginiana
5 Quercus Michauxii
4 Platanus occidentalis
4 Quercus nigra
4 Fraxinus sp.
4 Celtis sp.
4 Acer rubrum tridens?
3 Planera aquatica
3 Quercus lyrata
3 Ulmus americana?
2 Morus rubra
2 Carpinus caroliniana
2 Ilex opaca
2 Nyssa sylvatica
2 Hicoria ovata
2 Quercus texana?

SHRUBS

25 *Brunnichia cirrhosa*
18 Sabal glabra
6 Sambucus canadensis
5 Arundinaria macrosperma
3 Cephalanthus occidentalis
3 *Tecoma radicans*
2 *Rhus radicans*
2 Bignonia crucigera
2 *Berchemia scandens*
2 Adelia acuminata

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* Also (perhaps more commonly) spelled Belzona.

† Some of this may be *Ulmus crassifolia*, which I was not acquainted with at that time.

HERBS

14	Anthemis Cotula	2	Carex Crus-corvi
4	Daucus pusillus	2	Ambrosia artemisiaefolia
4	Sorghum Halepense	2	Saururus cernuus
3	Cyperus pseudovegetus	2	Monarda citriodora
3	Dracopis amplexicaulis		

There are probably few places in temperate regions where one can see more species of trees in traveling a similar distance through an essentially homogeneous region. Six of those listed are oaks, and if I had been more familiar with the Mississippi valley representatives of that genus I might have identified still more. The only evergreen tree in the list is *Ilex opaca*,* and that is confined to the highest and driest spots, and constitutes considerably less than 1 per cent of the arboreal vegetation. As in other hardwood regions,† the woody plants greatly outnumber the conspicuous native herbs. The abundance of woody vines seems to be characteristic of alluvial habitats and some other rich soils, in various parts of the world.‡ The herbs listed are nearly all weeds.

Taxodium distichum, the commonest tree, is not found on the banks of the navigable streams of the delta, for it apparently cannot stand more than ten or twelve feet of average seasonal fluctuation of water.§ It abounds along the smaller bayous or "lakes," and in the interstream swamps described by Smith, Hilgard and others. At the time of my visit the branches of most of the cypress trees in this region and among the bluffs near Carrollton had many branches dead at the tips. The cause of this condition was not ascertained, but drainage operations may have had something to do with it.

Populus heterophylla, which is said by Sargent‖ to be especially abundant in this region, I saw only once, and that in the outskirts of the city of Greenwood, where it might not have been indigenous.

Besides the species to be noted presently as conspicuous by their absence all the way across the state, the following were not seen at all in the "delta":

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* This seems to be the only angiospermous evergreen tree in New England and in several interior states.

† See Bull. Torrey Club **37**: 411–412. 1910.

‡ See Torreya **10**: 62. 1910.

§ See Science II. **36**: 760–761. 28 No 1912.

‖ Silva N. A. 9: 164. 1896.

Terrestrial ferns
Pinus (all species)
Juniperus virginiana
Alnus rugosa
Fagus
Quercus stellata
Quercus falcata
Quercus marylandica
Liriodendron
Sassafras
Nyssa biflora

Banks of the Mississippi (PLATE 22). Of the banks of the "Father of Waters" I can say very little, having seen them only for a few miles, between Greenville, Miss., and Luna Landing, Ark., on June 10th. Nuttall passed by there in January, 1820, and published some observations on the river-bank vegetation in his "Journal of travels into the Arkansa territory" the following year. Lyell traversed part of the same route in March, 1846, and his observations can be found in his "Second visit to the United States," 2: 163–164. 1849.

On the inner sides of bends *Salix nigra* (?) is seen everywhere on sand-bars between high and low water marks, and *Populus deltoides* on more silty soil a little higher up. These trees can probably stand as much seasonal fluctuation as any in the world. They seem to prefer soils poor in nitrogen and rich in inorganic plant foods, and they must be regarded as the pioneers for that particular type of soil. On the outer sides of bends, where the river is eroding its banks, *Liquidambar*, *Arundinaria*, and various other species characteristic of river-bottoms are visible, together with occasional specimens of *Taxodium* in the swamps farther back.

CONCLUSION

Notable absentees. Of the plants which are common in other parts of the coastal plain and rare or absent in northern Mississippi the following occur to me. *Nyssa biflora* was seen only twice, once in Clay County and once in Lowndes; and *Juniperus* was seen only once on the 1911 trip, that in Lowndes County. (It is rather common in the black belt of Alabama.) Ferns are rare, as are nearly all pine-barren plants. The following were not seen at all.

Pinus palustris
Taxodium imbricarium
Tillandsia*
Orchidaceae
Myrica cerifera
Magnolia (all species)
Ericaceae

* In crossing the "delta" I must have been pretty close to the range of *Tillandsia usneoides*, for Nuttall (Travels, 228), in floating down the Mississippi on Jan. 22,

Relation of flora to precipitation and soil texture. The absence of *Taxodium imbricarium*, *Magnolia glauca*, and other bog plants from northern Mississippi is correlated with the seasonal distribution of rainfall, among other things. In the greater part of the coastal plain, summer is the rainy season; but in the "Mississippi embayment" portion, which is farthest inland, the winters are wetter than the summers, just as in the interior hardwood region, of which this might be regarded as forming a part. At Water Valley, Yalobusha County, which is pretty close to the center of the northern half of Mississippi, meteorological records for a period of twenty years show that only 30.3 per cent of the normal annual precipitation comes in the four warmest months, June to September, and 41.9 per cent in the six warmest months, May to October.* (March is usually the wettest month and October the driest.)

This type of seasonal distribution of rainfall makes all streams, and the ground-water too, high in spring and low in fall; while in the pine-barren portions of the coastal plain the greater evaporating power of the sun in summer is largely counterbalanced by the increased rainfall at that season, and consequently the water-level is much more uniform there, and conditions are favorable for the development of peat and of bog plants. Ponds and swamps are scarce in northern Mississippi, except in the "delta," where they are caused by the topography, in spite of the climatic conditions just described.

Another factor perhaps still more important in determining

1820, first met it at Cypress Bend, about 20 miles below the mouth of the Arkansas River; and one of the bends near Greenville is named "Spanish Moss Bend." The same plant was reported from along the Cumberland River in Stewart County, Tennessee, by Dr. J. M. Safford, state geologist of Tennessee, in Garden & Forest **3**: 81. 1890.

* For data of seasonal distribution of rainfall in some other parts of the coastal plain see Bull. Torrey Club **37**: 415–416 (footnote). 1910; Florida Geol. Surv. Ann. Rep. **3**: 215. 1911. The interior hardwood region has been briefly defined in Torreya **12**: 146. 1912. The map by Gannett there referred to shows for the whole United States the percentage of rainfall for "the six warmer months, April to September inclusive." But in most places in the eastern United States October is usually a little warmer than April; and furthermore it is usually drier than April in the regions that have dry summers, and wetter than April in the regions that have wet summers, so that the figures for May to October give greater contrasts than do those for April to September.

the character of the flora of northern Mississippi is the prevalence of clayey soils, contrasting strongly with the sand of the pine-barrens nearer the coast. Sand is here chiefly confined to the beds of creeks and rivers, as it is in most of the interior hardwood region. The character of the soil may not be wholly independent of the seasonal distribution of rainfall, but it would be too much of a digression to discuss the matter here. Suffice it to say that it happens that in the Eastern United States most regions with wet winters and dry summers have fertile clayey soils, and where the reverse is true sandy soils predominate.

Some relations of vegetation to soil chemistry. Dr. Hilgard, in his earliest and latest books (1860 and 1906), and in various other works, has always stressed the importance of chemical composition of soil, especially the percentage of lime, in determining the character of the vegetation. In his "Soils," page 490, as already noted, he gives the lime percentages for each soil belt of northern Mississippi, and describes the corresponding vegetation briefly. Similar correlations have been made in Europe by a number of investigators, and the fertility of calcareous soils has been long proverbial. Limestone is one of the commonest and most easily recognized minerals, so that such correlations are easily made; but in the light of the observations made on this trip, and other recent investigations, it is highly probable that some of the other mineral ingredients of soils which do not manifest themselves so conspicuously may be equally important to vegetation.

In the case of lime there always has been a difference of opinion as to just how much of it a soil should contain to be called calcareous. According to Dr. Hilgard, in Europe a soil is not usually called calcareous unless it effervesces with acid, which requires about 5% of lime (calculated as CaO)*; while in this country many soils containing only 1% of lime differ as much in their vegetation from those which have less as they do from some derived from nearly pure limestone. He concludes that calcareous soils are distinguished better by their vegetation than by any arbitrary chemical standard; but here another difficulty is encountered. Just what is calciphile vegetation?

Various European investigators, Schimper† for example, have

* In this connection see Plant World 15: 300–301. 1912.

† See pages 94–106 of his Plant Geography, English edition. 1903.

published lists of calciphile plants for particular regions, and in temperate eastern North America certain plants, mostly trees, have become by common consent, as it were, accepted as indicators of calcareous soils. Dr. Hilgard lists quite a number of these in each of his books, and even goes farther and distinguishes different forms of the same species characteristic of different kinds of soil. But none of these writers seem to mention any characters which their calciphile plants have in common, so that if a person totally ignorant of mineralogy should travel around the world he could identify the limestone regions only by knowing the individual species which have been listed as calciphile; and the flora changes almost completely every thousand miles or so in temperate regions.

As a matter of fact, the supposed lime-loving trees listed by Hilgard and others in this country do have some characters in common. They are all deciduous except the cedar (and I have recently shown that that is not necessarily calciphile*), and many of them have durable dark-colored heart-wood, thin leaves, and large seeds. But trees with similar characters, and indeed most of the same species, can be also found in many places where the soil is poor in lime or at least not commonly regarded as calcareous, and associated with other species which have not been hitherto regarded as calciphile. Coville in his work in Arkansas a quarter of a century ago found that the difference in the vegetation of sandstone and limestone areas in close proximity was more quantitative than qualitative; i. e., the species were nearly the same, but their relative abundance differed considerably in the two areas.†

Comparatively few observations on calciphile vegetation in tropical and cold-temperate regions seem to have been made. In Schimper's Plant Geography less than a page (380) is devoted to the effects of lime on vegetation in the tropics, and he believes its influence to be less there than in temperate regions. In extreme southern Florida, including the Keys and most of the mainland south of Miami, the rock is nearly all limestone,‡ and there

* Torreya 12: 145–154. 1912.

† See Arkansas Geol. Surv. Rep. 1888[4]: 246–247. 1891.

‡ I have no analyses of the mainland rock, but that of the Upper Keys is said to be over 90% calcium carbonate.

is very little soil on top of it. But almost none of the trees regarded as calciphile in the states farther north are found there, and the question arises, are the numerous species of trees growing on limestone in South Florida (nearly all of them tropical) true calciphiles? They are certainly very different in aspect from the supposed lime-loving trees of Mississippi, being nearly all evergreen. Furthermore, some of the commonest species, the pine especially, flourish equally well in sandy soils a little farther north, which are very poor from an agricultural standpoint.

Let us see now if there is not some soil ingredient other than lime which is of fundamental importance to vegetation. One of the most convenient and at the same time perhaps the most significant characters of arboreal vegetation that can be expressed quantitatively is the percentage of evergreens, and this has been already indicated roughly for most of the soil belts described above. The percentages of certain soil ingredients also have been given, and it will be noticed that in the regions under consideration the evergreens can be correlated with *potash* just about as well as with lime, evergreens being scarcest in the soils richest in potash. This relation is still more apparent when we compare northern Mississippi, where nearly all the soils are pretty well supplied with potash, with Florida, where soil conditions are very different. Florida has a larger proportion of evergreens than any other state in the Union, and at the same time its soils are poorest in potash, though fairly well supplied with lime.* It is altogether likely that the limestones of South Florida above mentioned are deficient in potash, though I have too few data on this point as yet. Statistics collected by Hilgard in his book on Soils show that the percentage of potash in tropical soils is usually less than in those of temperate regions; and it is barely possible that the prevalence of evergreens in the tropics may be due partly to this fact, and not to climate alone, as has been hitherto supposed. In temperate

* On page 11 of Bulletin 85 of the U. S. Bureau of Soils, published late in 1912, there is a table of the average chemical composition of the soils of each state, based on over a thousand analyses. The average of 88 samples from Florida is 0.03% of potash and 0.31% of lime. The corresponding figures for four typical hardwood states are as follows: Kentucky, 92 samples, 0.35% potash, 0.18% lime; Ohio, 57 samples, 0.25% potash, 0.29% lime; Tennessee, 144 samples, 0.28% potash, 0.20% lime; West Virginia, 14 samples, 0.53% potash, 0.16% lime.

climates evergreens abound in and near peat bogs and are scarce in clayey soils, and it is well known that potash is scarce in peat and abundant in clay.

Just why potash should be antagonistic to evergreens is an ecological problem that need not be discussed here; for at present I am merely pointing out the geographical correlation. The reasons why this correlation has not been made before are probably first because potassic rocks are not conspicuous and identifiable at sight like limestone, and second because the percentage of potash in the soil varies between much narrower limits than does that of lime, and most soils in inhabited regions have enough potash for the average plant. But it has been proved by many experiments that in an artificial soil containing no potash at all nothing will grow; and it is therefore reasonable to assume that between this artificial condition produced in the laboratory and natural soils containing an average amount of potash there must be intermediate stages where the vegetation is very different from what it is on the average soil. As potash seems to be more abundant in leaves than in any other part of a plant it is natural that a deficiency of this substance should manifest itself first in the leaves, and that plants which do not have access to much potash should have smaller leaves than those of rich soils, and keep them longer.

GEOLOGICAL SURVEY OF ALABAMA, UNIVERSITY

Explanation of plates 21, 22

FIG. 1. Level dry woods about two miles north of Sheppardtown, Leflore County, approximately on the "dogwood ridge." The most conspicuous trees are *Nyssa sylvatica* (in foreground), *Quercus nigra*, and *Ilex opaca*. June 8, 1911.

FIG. 2. Bayou at Quito, Leflore County, looking west from wagon bridge. Trees mostly *Taxodium distichum* and *Nyssa uniflora*. The dead branches in the water indicate the absence of current. June 8, 1911.

FIG. 3. Eroding bank of Mississippi River on outer side of bend about two miles above Greenville, Washington County. Shows *Taxodium distichum*, *Populus deltoides*, *Salix*, etc. June 10, 1911.

FIG. 4. Nearer view of same (eastern) bank of river a little farther upstream, showing numerous vines, *Platanus occidentalis*, etc. June 10, 1911.

Studies in the Agalinanae, a subtribe of the Rhinanthaceae*

Francis W. Pennell

II. Species of the Atlantic coastal plain

Following a survey of the nomenclatural history of the group of Rhinanthaceous plants, which we would term for convenience the Agalinanae, there should properly come some comparative morphological study of the several genera. It has seemed advisable, however, to defer such for the present, in order first to present the results of a season's field-study of the group in the Coastal Plain of the South Atlantic and East Gulf states.

The present paper includes a revision of the species known to occur in the Atlantic Coastal Plain from New Jersey to eastern Louisiana. The flora of the northward extension of this area—Long Island and southeastern Massachusetts—has not been included, as this region is so narrow and broken, and the Coastal Plain flora so attenuated, as scarcely to make such inclusion desirable. From New Jersey southward and westward to central Alabama the Fall Line has been followed as the natural inland boundary. But toward the west instead of turning northward to include the lower Mississippi Valley, an arbitrary line has been drawn on the 33d parallel to the Mississippi River, the western limit of this study. It is believed that while sufficiently diverse the flora of the region included has so much in common, and so much in contrast to the districts northward and westward as to warrant a special consideration.

Four genera of Agalinanae occur within this area. Of these *Macranthera* is monotypic and wholly restricted to this region, *Afzelia* with two species east of the Mississippi River is nearly so restricted, *Aureolaria*, primarily a genus of the Appalachian district, has several species adapted to this region, while *Agalinis*, the largest genus, here reaches its greatest diversity and abundance.

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* Contribution from the Botanical Laboratory of the University of Pennsylvania.

In the late summer and early autumn of 1912, I was able to spend over two months in field-study of this group, and the following itinerary indicates the more important points in the Coastal Plain where collections were made:

Abita Springs, St. Tammany Parish, Louisiana	August	11–19
Catalpa, West Feliciana Parish, Louisiana	"	20–26
Biloxi, Harrison Co., Mississippi	"	27–29
Theodore, Mobile Co., Alabama	August 30–Sept.	4
Mobile, Mobile Co., Alabama	Sept.	5
Bay Minette, Baldwin Co., Alabama	"	6–8
Milton, Santa Rosa Co., Florida	"	9
Milligan, Santa Rosa Co., Florida	"	10
Florala, Covington Co., Alabama	"	11–15
Chipley, Washington Co., Florida	"	16–18
Apalachicola, Franklin Co., Florida	"	19–21
Tallahassee, Leon Co., Florida	"	22–24
St. Marks, Wakulla Co., Florida	"	25–26
Monticello, Jefferson Co., Florida	"	27
Thomasville, Thomas Co., Georgia	"	28–30
Valdosta, Lowndes Co., Georgia	Oct.	1
Cordele, Crisp Co., Georgia	"	2–4
Douglas, Coffee Co., Georgia	"	4
Waycross, Ware Co., Georgia	"	5–6
Jacksonville, Duval Co., Florida	"	7–8
Brunswick, Glynn Co., Georgia	"	9–10
Charleston, Charleston Co., South Carolina	"	11–13
Monks Corner, Berkeley Co., South Carolina	"	14
Wilmington, New Hanover Co., North Carolina	"	15–16
Rocky Mount, Nash Co., North Carolina	"	17
Weldon, Halifax Co., North Carolina	"	18

Altogether about 300 numbers of Agalinanae were collected, and a field-study of each species made. These collections and notes form the basis of this report.

In connection with this material I have also reviewed the specimens from the Coastal Plain in the herbaria of the following institutions: United States National Museum, Missouri Botanical Garden, Field Columbian Museum, Biltmore Herbarium, New York Botanical Garden, Academy of Natural Sciences of Philadelphia, University of Pennsylvania, Charleston Museum, Tulane University, Florida Agricultural College, also in the private herbaria of Dr. E. L. Greene, C. C. Deam and H. H. Bartlett. To the custodians and owners of all of these I am greatly indebted.

Also I am indebted to Dr. N. E. Brown of Kew Gardens, England, for consulting Bentham's types in their collections, portions of three of which were kindly sent me; to Dr. A. B. Rendle of the British Museum for examining Walter's types; and to Dr. C. H. Ostenfeld of Copenhagen, Denmark, for comparing the type of *Gerardia tenuifolia* Vahl.

Of the thirty-four species and subspecies in the following pages, all but one have been seen and studied in the field. This exception, *Agalinis oligophylla*, is a Louisiana species not in flower in August when I was there. All new species here proposed have been seen growing, and compared with allies in their native environment. It has been a matter of no small satisfaction that herbarium material since reviewed has fallen so readily into the species deemed valid in the field.

A word may be said concerning field variation in this group. The one species of *Macranthera* and our two of *Afzelia*, as well as all our species of *Agalinis* seem relatively uniform and constant. Breaks between species in the last are often slight but field-study shows them to be true—I have observed little in this genus to suggest hybridism or pronounced subspecific variation. On the other hand, in *Aureolaria*, especially in the subgenus *Panctenis*, conditions seem much more complicated, and such a species as *Aureolaria pectinata* can be viewed only as composed of a number of strains.

In the following treatment the endeavor is made to include quite fully diagnostic characters in the key, while, to save space, only in the case of new species are specific descriptions given. Full synonomy is included so far as Coastal Plain species are concerned. Type localities are quoted from the original descriptions, and where types have been examined the fact is noted. No types have been found for Rafinesque's species. The type of *Gerardia tenuifolia leptophylla* Benth.* has not been as yet identified. The flowering and fruiting seasons are from specimens seen, but are necessarily incomplete. North and south the flowering season is about the same for a given species, possibly a little later south. All definiteness in season seems to be lost in southern

* Hook. Comp. Bot. Mag. 1: 174. 1835. "Jacksonville, Louisiana." *G. tenuifolia filiformis* Benth. in DC. Prodr. 10: 518. 1846, is the same plant.

Florida. Distribution notes are made as definite as practicable.* All localities from which specimens have been seen are listed, and in the case of specimens of my own collecting numbers are given. Of course many specimens have been seen with data too vague for such classification. In the fuller revision of this group upon which the writer is working it is intended more fully to index specimens seen.

In prosecuting this study I have been most deeply indebted to the following three gentlemen: to Mr. Roberts Le Boutillier, of Wayne, Pa., whose generosity enabled me to accomplish the field-work required, to Dr. Roland M. Harper whose knowledge of the flora of the Southeast, most generously imparted, has made my search far more successful than it otherwise could have been, and to Dr. John M. Macfarlane, under whose direction and constant support this study has been made.

Key to the coastal plain genera

Corolla tubular, orange, its base thickened, fleshy, semi-persistent, shriveling and blackening before falling. Filaments equal, long-exserted, pubescent with beaded hairs. Anther-sacs closely parallel, opening their entire length. Capsule ovoid, acuminate, densely and closely pubescent. Seeds winged. 1. *Macranthera.*

Corolla with inflated throat or spreading lobes, yellow or purple, not fleshy nor semi-persistent. Filaments not long-exserted, pubescence not beaded.

Corolla nearly rotate, tube short, lobes longer than tube, yellow. Filaments nearly equal, about the length of the corolla-tube; anther-sacs closely parallel, opening by short apical slits. Capsule ovoid, acute. Seeds wingless or winged. 2. *Afzelia.*

Corolla with inflated throat, tubular-campanulate, lobes much shorter than tube. Filaments didynamous, included; anther-sacs opening their entire length.

Corolla yellow. Anther-sacs parallel, awned at base. Capsule acute to acuminate. Seeds wingless or winged. 3. *Aureolaria.*

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* In summarizing local distribution I have largely adopted the floristic areas outoutlined in the following publications: W. Stone—Plants of Southern New Jersey—Ann. Rep. New Jersey State Mus. [1910]: 1912; F. Shreve *et al.*—Plant Life of Maryland—Maryland Weather Service 3: 1910; R. M. Harper—Vegetation of the coastal plain—Bull. Torrey Club 37: 405–428, 1910; R. M. Harper—Altamaha Grit Region of Georgia—Ann. New York Acad. Sci. 17: 1. 1906. R. M. Harper—Preliminary Report on Peat—Florida Geol. Surv., Ann. Rep. 3: 199–375. 1911; C. Mohr—Plant Life of Alabama—Contrib. U. S. Nat. Herb. 6. 1901; R. M. Harper—Geographic Report on Forests—Geol. Surv. Alabama Monograph 8. 1913.

Corolla pink or purple. Anther-sacs more or less divergent, obtuse to mucronate-awned at base. Capsule rounded at apex. Seeds wingless. 4. *Agalinis.*

1. MACRANTHERA "Torr."; Benth. in Hook. Comp. Bot. Mag. 1: 174. 1835–6

One species:

1. MACRANTHERA FLAMMEA (Bartram) Pennell, Bull. Torrey. Club 40: 124. 1913

Gerardia flammea Bartram, Trav. 412. 1791. "Stony gravelly heights" along Tensaw River* near "Taensa," Alabama. No type specimen known to exist. Identified by Mohr, Plant Life of Alabama, 15. 1901.

Conradia fuschioides Nutt. in Jour. Acad. Nat. Sci. Phila. 7: 88. 1834. No locality given. Type, without data, seen in Herb. Acad. Nat. Sci. Phila.

Macranthera fuchsioides (Nutt.) Benth. in Hook. Comp. Bot. Mag. 1: 174. 1835–6.

Macranthera Lecontei Torr. in Ann. Lyc. Nat. Hist. New York 4: 80. *pl. 4.* 1837. "In dry pine woods on the Alatamaha, in Liberty County, Georgia." Type, without data, seen in Herb. Columbia University.

Russelia flammea (Bartram) Raf. New Fl. Am. 2: 71. 1837.

Flamaria coccinea Raf. New Fl. Am. 2: 71. 1837. Additional name for *Russelia flammea* (Bartram) Raf.

Toxopus gymnanthes Raf. New Fl. Am. 2: 72. 1837. Additional name for *Macranthera Lecontei* Torr.

Toxopus calycinus Raf. New Fl. Am. 2: 72. 1837. Additional name for *Macranthera fuchsioides* (Nutt.) Benth.

Tomilix bracteata Raf. New Fl. Am. 2: 72. 1837. Additional name for *Macranthera fuchsioides* (Nutt.) Benth.

Macranthera fuchsioides Lecontei (Torr.) Chapm. Fl. So. U. S. 297. 1860.

Conradia Lecontei (Torr.) Kuntze, Rev. Gen. 1: 459. 1891.

Though somewhat variable, when in flower the calyx-lobes are mostly entire, linear, relatively short as compared with corolla-tube [= M. Lecontei], later the corolla shrivels and

* Eastern arm of Mobile River.

contracts, but persists, while the calyx-lobes continue to grow, becoming quite lobed and leaf-like [= M. fuchsioides].

Flowers, August to October. Fruit, September to October.

DISTRIBUTION: Borders of wet sandy thickets, in lower coastal pine belt and coast district, southern Georgia and northern Florida to southern Mississippi. Frequent in pine hill region of northwestern Florida, and in southern Alabama. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Probably Liberty Co., *LeConte;* Thomasville.

Florida: Quincy; Beverly (*4681*); Argyle; Crestview; Milligan (*4595*); Milton (*4564*); Bluff Springs.

Alabama: McRae (*4641*); Bay Minette (*4553*); Mobile; Whistler (*4534*); Theodore (*4406, 4459, 4462*).

Mississippi: Ocean Springs; Biloxi.

2. AFZELIA J. F. Gmel. *curante* L. Syst. Nat. ed. 13. 927. 1791

Stem closely pubescent, viscid; leaves pinnatisected, segments lanceolate or broader; calyx-lobes lanceolate; corolla deep yellow, pubescent without, its lobes ovate, 3–3.5 mm. wide; anthers lanose with yellow hairs on dorsal side of connective; capsule ovate, 6–7 mm. long, densely short tomentose with brown hairs; seeds winged. Plant low, 2–6 dm. tall, widely branched. 1. *A. pectinata.*

Stem sparingly pubescent, scarcely glandular; leaves pinnatifid, segments filiform; calyx-lobes linear; corolla pale yellow, glabrous without, its lobes lanceolate, 1.5–2 mm. wide; anthers glabrous; capsule inversely pyriform, 4–4.5 mm. long, glabrous; seeds wingless. Plant tall, 5–10 dm., virgately branched. 2. *A. cassioides.*

1. AFZELIA PECTINATA (Pursh) Kuntze, Rev. Gen. 1: 457. 1891

Seymeria pectinata Pursh, Fl. Am. Sept. 2: 737. 1814. "In South Carolina. *Catesby—v. s. in Herb. Sherard.*"

Seymeria Jacksoni Ell. Sketch 2: 123. 1824. "Sent to me from Louisville, Ga., by Mr. Jackson." Type seen in the Elliott Herbarium at the Charleston Museum.

Seymeria heterophylla Raf. New Fl. Am. 2: 68. 1837. "Alabama and Georgia, my specimen from Leconte."

Flowers, August to September. Fruit, mid-September to October.

DISTRIBUTION: Dry sandy pineland in the coastal plain from

South Carolina to Mississippi, south in the Florida peninsula to Miami. Frequent in southern Georgia and southern Alabama and in Florida. Nearly restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

South Carolina: Aiken.
Georgia: Augusta; Thomson; Louisville; Brunswick (*4845*); Waycross (*4780*); Thomasville (*4732*); Leslie (*4760*); Columbus.
Florida: Jacksonville; South Jacksonville; San Pablo (*4802*); St. Augustine; Tocoi; Eustis; Palm Springs; Clarcona; Georgiana; Miami; Marco; Tampa; St. Marks (*4705*, *4715*); Quincy; River Junction; Liberty Co.; Fort Gadsden (*4686*); Apalachicola (*4674*); Chipley (*4645*); Ponce de Leon (*4656*); Milligan (*4585*); Milton (*4568*); Santa Rosa Island.
Alabama: Auburn; Abbeville; Ozark; Florala (*4630*); Greenville; Wilcox Co.; Mobile Co.
Mississippi: Waynesboro.

2. AFZELIA CASSIOIDES (Walt.) J. F. Gmel. *curante* L. Syst. Nat. ed. 13. 927. 1791

Anonymos cassioides Walt. Fl. Carol. 171. 1788. No type locality given, presumably from Berkeley Co., South Carolina.
Gerardia cassioides (Walt.) Pers. Syn. 2: 154. 1807.
Seymeria tenuifolia Pursh, Fl. Am. Sept. 2: 737. 1814. New name for *Gerardia cassioides* (Walt.) Pers.

Flowers, September to mid-October. Fruit, October.

DISTRIBUTION: Moist to dry pineland, mostly sandy, in the coastal plain from North Carolina to Florida and Louisiana. Frequent in the Wilmington pine barrens, occurs also near Fayetteville, North Carolina, and occasional or frequent southward. Most abundant in flat pine woods of southern Georgia, northern Florida, and near the Gulf coast to Louisiana. In the Florida peninsula reaching Bradentown on the west coast. Mostly in the coastal plain, casually inland in northern Georgia, Alabama, and southeastern Tennessee.

PLANTS AND SPECIMENS EXAMINED:

North Carolina: Wilmington (*4900*, *4919*); Fayetteville.
South Carolina: Columbia; Santee Canal; St. Johns; Cooper

River; Monks Corner (*4878*); Otranto (*4872*); Summerville; Charleston (*4866*); Beaufort.

Georgia: Thalmann (*4809*); Coffee Co.; Naylor (*4743*); Moultrie; Thomasville (*4725*); Leslie.

Florida: Jacksonville; St. Augustine; Bradentown; Tampa; Lake City; Monticello (*4719*); St. Marks (*4713*); Quincy; River Junction; Fort Gadsden (*4691*); Apalachicola (*4678*); Chipley (*4649*); Ponce de Leon (*4653*); Milligan (*4588*).

Alabama: Auburn; Abbeville; McRae (*4639*); Bay Minette (*4552*); Mobile Co.

Mississippi: Meridian; Fontainebleau; Ocean Springs; Biloxi; Nicholson.

Louisiana: Covington (*4217*); Hammond.

3. AUREOLARIA Raf. New Fl. Am. 2: 58. 1837

Corolla glabrous without; calyx-lobes entire; seeds winged. Plants perennial, not glandular. Capsule glabrous. Flowers evidently pediceled. Stem glabrous, more or less glaucous. Leaves glabrous beneath. — **Aureolaria** (*sensu strictu*).

Stem quite glaucous. Bracts of a lanceolate type, some at least dentate like the leaves. Capsule 15–20 mm. long. — 1. *A. virginica.*

Stem slightly glaucous. Bracts of a spatulate type, entire. Capsule about 12–15 mm. long. — 2. *A. reticulata.*

Stem puberulent. Leaves puberulent beneath. Bracts of a spatulate type, entire. — 3. *A. dispersa.*

Capsule rusty-pubescent. Plant pubescent throughout. Flowers very short-pediceled. — 4. *A. villosa.*

Corolla pubescent without; calyx-lobes dentate to pectinate; seeds wingless. Plants annual, glandular. — **Panctenis** (Raf.) subgenus nov.*

Leaves and stem minutely pubescent or minutely glandular. Pedicels mostly over 10–12 mm. long, exceeding the calyx. Leaves not sharply incised. Calyx-tube turbinate. Capsule ellipsoid.

Leaves and stem minutely and closely pubescent. Leaves deeply pinnatifid. Stem-leaves mostly 3–6 cm. long.

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* *Gerardia* sect. *Pedicularioides* Benth. in Hook. Comp. Bot. Mag. 1: 205. 1835–6, if sectional names have full standing, has priority over *Panctenis* Raf. New Fl. Am. 2: 60. 1837.

Pedicels mostly shorter than or equaling the bracts. 5. *A. pedicularia.*

Stem-leaves mostly less than 2 cm. long. Pedicels longer than the bracts. 6. *A. pedicularia caesariensis.*

Leaves and stem minutely glandular-pubescent. Leaves shallow-pinnatifid, those of the stem mostly 2–3 cm. long. 7. *A. pedicularia carolinensis.*

Leaves and stem densely glandular-pubescent.

Pedicels mostly less than 10–12 mm. long, shorter than the calyx. Leaves pinnately lobed, lobes sharply pectinate. Calyx-tube hemispheric. Capsule broadly ovoid.

Stem-leaves all spreading. Flowering pedicel 5–10 mm. long. Flowers about 35 mm. long. Plant widely branched, uppermost leaves smaller, but not excessively reduced. 8. *A. pectinata.*

Stem-leaves, at least the upper, appressed-ascending. Flowering pedicel mostly less than 5 mm. long. Flowers about 40–45 mm. long. Plant virgately branched, uppermost leaves much reduced. 9. *A. pectinata floridana.*

1. **Aureolaria virginica** (L.) Pennell, comb. nov.

Rhinanthus virginicus L. Spec. Plant. 603. 1753. "Habitat in Virginia." Specimen in Gronovius' herbarium identified by Pursh. As specimen in Linnaean Herbarium bears handwriting of Linnaeus the younger, and was probably a later addition, I presume Gronovius' plant to be the type. For discussion see Kuntze, Rev. Gen. 1: 460. 1891.

Gerardia flava L. Spec. Plant. 610. 1753. "Habitat in Virginia, Canada." Specimen in Linnaean Herbarium identified by Bentham in Hook. Comp. Bot. Mag. 1: 198. 1835–6.

Anonymos flava (L.) Walt. Fl. Carol. 170. 1788. As to synonymy, not description, the latter probably applying to *Aureolaria villosa* Raf.

Gerardia lauca Eddy in Med. Repos. N. Y. IInd. Hexade, 5: 126. 1807. Plandome, Long Island. *C. W. Eddy.*

Gerardia quercifolia Pursh. Fl. Am. Sept. 2: 423. 1814. "On the banks of rivers in rich shady places, Pennsylvania to Carolina."

Aureolaria glauca (Eddy) Raf. New Fl. Am. 2: 60. 1837.
Dasystoma quercifolia (Pursh.) Benth. in DC. Prodr. 10: 520. 1846.
Dasystoma flava (L.) Wood, Class Book. 529. 1861. As to synonymy, not description, the latter applying to *Aureolaria villosa* Raf.
Gerardia virginica (L.) Britton, Prelim. Catal. N. J. Pl. 40. 1888.
Dasystoma virginica (L.) Britton in Mem. Torrey Club 5: 295. 1894.

Flowers, in New Jersey, September.

DISTRIBUTION: Frequent on rich slopes, often rocky, in woodland inland, very rare in the Coastal Plain. On wooded slopes at a few points in southern New Jersey.

SPECIMENS EXAMINED:

New Jersey: New Egypt; Nesco; Fairton.

2. AUREOLARIA RETICULATA Raf. New Fl. Am. 2: 59. 1837

Aureolaria reticulata Raf. "Florida and Alabama." No type known to exist.
Dasystoma bignoniiflora Small in Bull. N. Y. Bot. Gard. 1: 285. 1899. "Collected by Dr. Burrows, at Tampa Bay, Florida, in 1834." Type seen in Herb. Columbia University.

Flowers, late-August to mid-October. Fruit, September to October.

DISTRIBUTION: Sandy ravines and moist woodland, both in calcareous and siliceous districts, in the coastal plain from North Carolina to central and western Florida. Apparently most frequent in calcareous region of northern and western Florida. Restricted to the coastal plain; possibly better considered a subspecies of *A. virginica* replacing that species in the southern coastal plain.

PLANTS AND SPECIMENS EXAMINED:

North Carolina: Fayetteville.
South Carolina: Santee Canal; St. Johns; Monks Corner (*4875*); Eding Island.
Georgia: Thomasville (*4723*); Leslie (*4765*).
Florida: Tampa Bay; Monticello (*4720*); Tallahassee (*4696, 4698*); River Junction; Marianna; Milton (*4565, 4566*).

3. **Aureolaria dispersa** (Small) Pennell, comb. nov.

Dasystoma quercifolia intermedia Benth. in DC. Prodr. 10: 520. 1846. No type locality given, nor type specimen known to exist. Description would indicate this species.

Dasystoma dispersa Small, Bull. Torrey Club **28**: 452. 1901. "Louisiana: Feliciana, *Carpenter;* type in the herbarium of Columbia University." Type seen in Herb. Columbia University.

Gerardia dispersa (Small) K. Schum. in Just's Bot. Jahresber. **29**: 580. 1903.

Flowers, August to September. Fruit not seen.

DISTRIBUTION: Sandy thickets and oakland, frequent in coastal pine belt near the Gulf, southern Alabama to eastern Louisiana, reaching Wilkinson Co., Mississippi. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Alabama: Baldwin Co.; Crichton (*4521*); Hollander's Island (*4504*).

Mississippi: Ocean Springs; Biloxi (*4384*); Long Beach; Wilkinson Co.

Louisiana: Abita Springs (*4117, 4245*); Covington; Feliciana.

4. AUREOLARIA VILLOSA (Muhl.) Raf. New Fl. Am. 2: 59. 1837

Aureolaria villosa (Muhl.) Raf. No type locality given, nor type specimen known to exist. *Gerardia villosa* Muhl. Catal. 58, 1813, and *Gerardia heterophylla* Muhl. l. c. are treated as nomina subnuda.

Dasystoma pubescens Benth. in DC. Prodr. 10: 520. 1846. "In Americae sept. civitatibus orientalibus frequens."

This species has been commonly identified as *Gerardia flava*, but appears not to be *G. flava* L.

Flowers, late-May to mid-August. Fruit, late-July to October.

DISTRIBUTION: Widely distributed in the eastern United States, more common above the fall line. Frequent or occasional in sandy soil in the coastal plain from New Jersey to Louisiana. Not seen from the Florida peninsula. In New Jersey frequent in middle and Cape May districts, less so in the pine barrens.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: Spotswood; Farmingdale; Hornerstown; Medford; Locust Grove; Westville; Clarksboro; Swedesboro; Atco (*3546*); Hammonton; Cape May Court House (*3986*); Bennett; Cold Spring; Cape May.
Maryland: Chestertown.
Virginia: Naucks (*2471*); Cape Henry; Franklin.
North Carolina: Wilmington.
South Carolina: Santee Canal; St. Johns; Bluffton; Aiken; Graniteville.
Georgia: Macon.
Florida: Jacksonville; Chattahoochee River.
Alabama: Ozark Evergreen.
Louisiana: Pearl River.

5. AUREOLARIA PEDICULARIA (L.) Raf. New Fl. Am. 2: 61. 1837

Gerardia pedicularia L. Sp. Pl. 611. 1753. "Habitat in Virginia, Canada."
Anonymos pedicularia (L.) Walt. Fl. Carol. 170. 1788. As to synonymy, probably not description.
Panctenis pedicularia (L.) Raf. New Fl. Am. 2: 61. 1837.
Dasystoma pedicularia (L.) Benth. in DC. Prodr. 10: 521. 1846.

Variable, the following subspecies local, and more or less sharply defined.

Flowers, mid-August to mid-September. Fruit, October. persisting through the winter.

DISTRIBUTION: Widely distributed and frequent in the northern states above the fall line. Rare in the coastal plain where mostly replaced by the following subspecies. Material seen nearly all from New Jersey, where it is rare or absent in middle district, somewhat more frequent in the pine barrens and evidently approaching the subspecies *caesariensis*. (Transitional specimens indicated by asterisk.)

PLANTS AND SPECIMENS EXAMINED:

New Jersey: Middlesex Co.; Brindletown*; Atsion*; Hammonton*.
Pennsylvania: Tinicum (*3589*).

6. **Aureolaria pedicularia caesariensis** Pennell, subsp. nov.

Annual. Stem 10 dm. tall, widely branching, minutely and closely pubescent, very sparingly glandular below. Leaves sessile, ovate-lanceolate, less than 2 cm. long, pinnatifid, segments irregularly crenate-dentate, equaling or longer than the width of the central portion of the lamina, minutely and closely pubescent. Pedicels slender, glandular, 15 mm. long, longer than the calyx, longer than, mostly twice exceeding, the bracts. Calyx-tube glandular with short-stalked glands, equaled by the dentate calyx-lobes. Corolla 35 mm. long, yellow. Capsule 10–12 mm. long, elliptic-ovoid, minutely glandular, surpassing the calyx-lobes.

Type, Atco, Camden Co., New Jersey, Sept. 7, 1911, *F. W. Pennell 3545* in Herb. University of Pennsylvania.

Flowers, mid-August to mid-September. Fruit, October, persisting through the winter.

DISTRIBUTION: Dry sandy pine and oak woods, frequent in the pine barrens of New Jersey, where it mostly replaces the species.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: East Plains; Bamber; Woodmansie; Taunton; Atco (*3545, 3627*); Middletown, Cape May Co.

7. **Aureolaria pedicularia carolinensis** Pennell, subsp. nov.

Annual. Stem 10 dm. tall, widely branching, minutely glandular-pubescent. Leaves sessile, ovate-lanceolate, 2–3 cm. long, pinnatifid-lobed, segments somewhat crenate, shorter than the width of the central portion of the lamina, minutely glandular-pubescent. Pedicels slender, glandular, 10–20 mm. long, longer than the calyx. Calyx-tube glandular with short-stalked glands, mostly exceeded by the incised-dentate calyx-lobes. Corolla 35 mm. long, yellow. Capsule 12 mm. long, elliptic-ovoid, minutely glandular, equaling or barely surpassing the calyx-lobes.

Type, savannahs near Mill Pond, Wilmington, North Carolina, June 23, 1909, *J. M. Macfarlane* in Herb. University of Pennsylvania.

Flowers, June to September. Fruit, October.

DISTRIBUTION: Dry sandy pine and oak woods, pine barrens of southeastern North Carolina, where it probably replaces the species.

PLANTS AND SPECIMEN EXAMINED:

North Carolina: Wilmington (*4925*) (J. M. Macfarlane in 1909; in 1911); "Southeastern North Carolina," *W. W. Ashe.*

8. **Aureolaria pectinata** (Nutt.) Pennell, comb. nov.

Gerardia pedicularia pectinata Nutt. Gen. Plant. N. Am. 2: 48. 1818. "HAB. In the sandy pine forests of Carolina and Georgia." No type in Herb. Acad. Nat. Sci. Philadelphia.

Gerardia pectinata (Nutt.) Benth. in Hook. Comp. Bot. Mag. 1: 206. 1835–6.

Panctenis pectinata (Nutt.) Raf. New Fl. Am. 2: 61. 1837.

Dasystoma pectinata (Nutt.) Benth. in DC. Prodr. 10: 52. 1846.

Very variable, as here understood, including a number of strains.

Flowers, July to September. Fruit, September to October.

DISTRIBUTION: Dry sandy pineland, especially hilly, in the coastal plain, South Carolina, through southern Georgia, pine hills of northwest Florida, to Alabama and Mississippi, locally frequent extending above the fall line. In some of its forms occurring throughout the Gulf and Lower Mississippi Valley states.

PLANTS AND SPECIMENS EXAMINED:

South Carolina: Eutawville; Santee Canal; Monks Corner; Cooper River; Beaufort.

Georgia: Augusta; Thomson; Americus.

Florida: De Funiak Springs.

Alabama: Florala (*4625*); Flomaton; Prattville; Tensaw; Deer Park; Mobile; Spring Hill (*4532*).

Mississippi: Meridian; Jackson.

9. **Aureolaria pectinata floridana** Pennell, subsp. nov.

Annual. Stem about 10 dm. tall, much branched, glandular-villose. Branches virgate, ascending. Leaves sessile, ovate, those of the stem less than 2 cm. long, pinnatifid, segments pectinately toothed, glandular-villose; at least the upper leaves ascending or appressed to the stem or branches, the uppermost much reduced. Pedicels stout, 5 mm. long or less, shorter than the calyx, glandular-villose. Calyx-tube glandular-villose, much exceeded by the lanceolate, pectinate teeth. Corolla 40–45 (–50) mm. long, yellow, no purple markings within tube (in type specimens). Capsule 12–14 mm. long, broadly ovoid, glandular-pubescent, shorter than the calyx.

Type, Fort Gadsden, Franklin Co., Florida, Sept. 20, 1912, *F. W. Pennell 4683*, in Herb. University of Pennsylvania.

This may be *Gerardia pedicularia pectinata* Nutt., as the mention of short pedicels and very large flowers would suggest, but as *floridana* does not occur in South Carolina, though probably in the flat pine woods of southeastern Georgia, I retain the name for the prevalent species of the district cited. I have seen no old collections of *floridana* from Georgia.

Flowers, May to mid-October. Fruit, June to October.

DISTRIBUTION: Dry sandy pineland. Flat pine woods of Florida and southern Georgia, south to Polk Co., Florida; replacing the species.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Thomasville (*4724*).
Florida: Jacksonville; Pablo; St. Augustine; Eustis; Orange City; Lake Brantley; Polk Co.; Tampa; Marion Co.; Tallahassee; Fort Gadsden (*4683*); Apalachicola.

4. AGALINIS Raf. New Fl. Am. 2: 61. 1837

Perennial, from a running rootstock, glabrous throughout. Pedicels erect, 5–20 mm. long. Corolla slightly fleshy, pink, with darker spots, but no yellow lines within throat, pubescent without, pubescent within at base of upper lobes, 35–40 mm. long. Capsule globose, 5–6 mm. long. Seeds dark brown. [*Linifoliae.*] 1. *A. linifolia.*

Annuals, fibrous rooted, in most at least the upper surface of the leaf scabrous. Pedicels ascending or spreading. Corolla membranous, purple or pink, mostly with darker spots and two yellow lines within throat. Capsule globose or ovoid.

Corolla with lobes all spreading, pubescent within at base of upper lobes, more or less pubescent without.

Seeds dark brown. Plants darkening in drying. Calyx-tube not reticulate-venulose. Corolla purple or pink-purple. Flowers short- or long-pediceled. [*Purpureae.*]

Leaves uniform, linear to filiform-subulate.

Inflorescence of normal racemes; pedicels less than 10 mm. long. Seed-coat with dark brown ribs, between these mostly paler and minutely reticulated.

Leaves and calyx-lobes obtuse to acutish. Anther-sacs obtuse to acutish at base. Plant fleshy, bushy-branched below, with elongated racemes above. Pedicels reaching 10 mm. long. 2. *A. maritima.*

Leaves and calyx-lobes acute to acuminate. Anther-sacs mucronate to minutely awned at base. Plants not fleshy, more uniformly branched. Pedicels less than 5 mm. long.

Corolla purple or pink-purple, 2 yellow lines and darker spots present. Plants dull-green or purplish, much darkening in drying.

Stem smooth or minutely scabrellous. Axillary fascicles slightly or not developed, if present shorter than leaves.

Corolla 20–35 mm. long, rose-purple.

Corolla 25–35 mm. long, on evident pedicels 2–5 mm. long. Stem sparingly scabrellous. Leaves linear, those of the stem 1.5–3.5 mm. broad. Calyx-lobes triangular-lanceolate to triangular-subulate. 3. *A. purpurea.*

Corolla 20–25 mm. long.

Leaves narrowly linear to almost filiform. Calyx-lobes triangular-subulate to subulate. Stem essentially smooth.

Stem-leaves narrowly linear to almost filiform, 1.5–3 cm. long, mostly longer than the internodes, mostly curling in drying. Branches mostly simple, ascending, virgate. Axillary fascicles relatively well

developed. Pedicels 2–5 mm. long. — 4. *A. virgata.*

Stem-leaves 1–2.5 cm. long, mostly shorter than the internodes. More stiffly branched. Axillary fascicles scarcely or not developed. Flowers nearly sessile, on pedicels less than 2 mm. long. — 5. *A. pinetorum.*

Stem-leaves almost filiform, 1–2 cm. long, curling in drying. — 6. *A. delicatula.*

Corolla 15–18 mm. long, pink-purple. Flowers nearly sessile, on pedicels less than 2 mm. long. — 7. *A. Harperi.*

Stem scabrous. Axillary fascicles abundantly developed, mostly equaling leaves. — 8. *A. fasciculata.*

Corolla lavender-pink, no yellow lines nor darker spots evident, 15–18 mm. long. Plants bright-green, little darkening in drying. Stem smooth or nearly so. Axillary fascicles abundantly developed. — 9. *A. georgiana.*

Inflorescence of short or much broken racemes, some flowers, by slower or arrested

growth of stem apex, frequently appearing terminal. Pedicels over 5 mm. long.
Stem scabrous. Anther-sacs evidently awned at base, densely woolly over entire surface. Seed-coat with dark brown ribs, areas between these more or less hexagonal, pale and not reticulated. Stem-leaves opposite, axillary fascicles abundantly developed. Pedicels 15–40 mm. long. Corolla 25–30 mm. long. 10. *A. pulchella.*
Stem glabrous, or essentially so. Anther-sacs acute to minutely mucronate-awned at base, pubescent, glabrous over much of dorsal surface. Seed-coat with dark-brown ribs, areas between these elongated, scarcely paler, and scarcely or not reticulated.
Stem-leaves alternate, narrowly linear to filiform, semi-fleshy, 1–2 cm. long. Axillary fascicles abundantly developed. Pedicels 10–35 mm. long. Corolla 25–30 mm. long. 11. *A. filifolia.*
Stem-leaves opposite. Axillary fascicles scarcely developed or none.
Stem-leaves narrowly linear to filiform-setaceous, 1.5 cm. or longer. Seed-coat with fine parallel ridges, areas between these narrow.
Pedicels less than 30 mm. long. Corolla mostly 20–30 mm. long, rose-purple. Seed-coat with very fine parallel ridges. Plants densely and repeatedly branched, usually with filiform to setaceous leaves.
Pedicels 10–30 mm. long, longer than the bracts. Corolla mostly 20–25 mm. long. Leaves narrowly linear to filiform. Flowers not conspicuously "terminal." 12. *A. Holmiana.*

Pedicels less than 10 mm. long, mostly shorter than the bracts. Corolla mostly 25–30 mm. long. Leaves filiform-setaceous. Flowers conspicuously "terminal." 13. *A. setacea.*

Pedicels, at least in fruit, 25–50 mm. long, very slender, four to five times exceeding the bracts. Corolla 15–18 mm. long, pink-purple. Seed-coat with fewer and slightly heavier ridges. Plant very widely and laxly branched, the lower branches widely ascending. Leaves narrowly linear to filiform. 14. *A. laxa.*

Stem-leaves filiform-subulate, 1 cm. long or less, much shorter than internodes. Seed-coat with broader areas. Pedicels 5–15 mm. long. Calyx-lobes acute, 0.5 mm. long. Corolla 15–20 mm. long. Stem terete, grooved, not angular. 15. *A. oligophylla.*

Leaves dimorphic, basal oval-ovate, spreading, cauline, minute, scale-like, appressed. Pedicels less than 5 mm. long, many flowers appearing to terminate minute axillary branches. Calyx-lobes minute, subulate. Corolla 15–20 mm. long, pink-purple. Stem mostly 4-angled, often pubescent at base. 16. *A. aphylla.*

Seeds yellowish brown. Plants light green, not darkening in drying. Corolla pink. Flowers on pedicels longer than bracts. Calyx-tube reticulate-venulose, lobes minute, callose. [*Erectae.*]

Stem-leaves 2–2.5 cm. long, filiform-linear, acute. Corolla 15 mm. long, lobes more or less emarginate, 2 yellow lines and purple spots evident. 17. *A. decemloba.*

Stem-leaves 1–1.5 cm. long.

Corolla 15–20 mm. long, lobes more or less emarginate, 2 yellow lines and purple spots well developed. Pedicels slender. Leaves nearly filiform, acutish or acute. Plant relatively lax. 18. *A. tenella.*

Corolla 12–16 mm. long, lobes rounded to truncate, 2 yellow lines and purple spots slightly developed or suppressed. Pedicels stouter. Leaves linear, widening upward, obtusish to obtuse. Plant strict, stiff. 19. *A. erecta.*

Corolla bilabiate, two upper lobes ascending over stamens and style, glabrous within at base of upper lobes. Seeds dark brown. [*Tenuifoliae.*]

Corolla pubescent without, 2 upper lobes two-thirds length of lower 3, minutely ciliate, concave-arched. Pedicels, if exceeding the bracts, less than twice their length. Corolla 10–18 mm. long, purple. Leaves linear, those of the stem often broadly so. 20. *A. tenuifolia.*

Corolla glabrous without, 2 upper lobes less than one-half length of lower 3, conspicuously ciliate, flattened. Pedicels at least three times the length of the bracts.

Leaves filiform, those of the stem 1.5–2 cm. long. Pedicels 15–30 mm. long. Corolla rose-pink, 15–18 mm. long. Plant reaching 8 dm. tall, widely much branched. 21. *A. divaricata.*

Leaves minute, scale-like, those of the stem less than .2 cm. long. Pedicels 5–10 mm. long. Corolla lavender-pink, 10–13 mm. long. Plant less than 5 dm. tall, sparingly very laxly branched. 22. *A. filicaulis.*

1. AGALINIS LINIFOLIA (Nutt.) Britton in Britt. & Br., Ill. Fl. ed. 2. 3: 209. 1913

Gerardia linifolia Nutt. Gen. Pl. N. Am. 2: 47. 1818. "HAB. From Wilmington, North Carolina to Florida." Type, labeled "Carolina," seen in Herb. Acad. Nat. Sci. Philadelphia.

Agalinis perennis Raf. New Fl. Am. 2: 63. 1837. "My specimen is from Florida."

Flowers, mid-August to October. Fruit, September to November.

DISTRIBUTION: Wet pineland, and especially margins of ponds, in the coastal plain. Ellendale, Delaware; from Wilmington, North Carolina to southern Florida and near the Gulf coast to Louisiana. Most abundant in flat pine woods of southern Georgia and Florida, less frequent in the west Florida pine hills and in the Altamaha grit region of Georgia, occasional north of the Savannah River or west of Florida. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Delaware: Ellendale.

North Carolina: Wilmington; Brunswick Co.

South Carolina: Hartsville; Santee Canal; Eutawville.

Georgia: Everett; Brunswick (*4823*); Waycross (*4790*); Naylor (*4745*); Thomasville (*4729*); Sumter Co.; Columbus.

Florida: Tisomia (*4813*); Baldwin; Jacksonville (*4794*); St. Nicholas; San Pablo (*4807*); Cutler; Homestead; Camp Longview; Fort Myers; St. Petersburg; St. Marks (*4714*); Quincy; Fort Gadsden (*4690*); Apalachicola; Chipley (*4648*, *4666*); Ponce de Leon (*4654*); Paxton (*4600*).

Alabama: Elmore.

Mississippi: Biloxi.

Louisiana: Hammond.

2. AGALINIS MARITIMA Raf. in Med. Repos. New York. IInd. hex. 5: 361. 1808 (as *Gerardia*); New Fl. Am. 2: 62. 1837

Gerardia maritima Raf. "Found in the islands of Egg-Harbour, in New Jersey." No type known to exist.

Gerardia purpurea crassifolia Pursh Fl. Am. Sept. 2: 422. 1814. "In salt marshes, near New York."

Gerardia maritima grandiflora Benth. in Hook. Comp. Bot. Mag. 1: 208. 1835–6. "Texas, *Drummond*, 1st Coll."

Gerardia spiciflora Engelm. Bost. Jour. Nat. Hist. 5: 227. 1845. New name for *Gerardia maritima grandiflora* Benth.

Gerardia maritima major Chapm. Fl. So. U. S. 300. 1860. "Brackish marshes, Apalachicola, Florida." There are several collections of Chapman's of this species, but none, indicated as type, has been seen.

Flowers, April (on the Gulf coast) to mid-September. Fruit, August to September.

DISTRIBUTION: Salt marshes, along the Atlantic and Gulf coasts from New Jersey to Louisiana, locally frequent. Extending to Maine northward, in the south to Texas, Yucatan, Cuba and the Bahamas. Along the Gulf coast and Atlantic coast in Florida a much branched plant, reaching 6 dm. tall, leaves and calyx-lobes more liable to be acutish, pedicels mostly exceeding the bracts, corolla reaching 20 mm. long, and anther-sacs lanose-

pubescent, northward becoming progressively smaller and simpler, till a plant of but 0.5–1.0 dm. tall in Maine, leaves and calyx-lobes constantly obtuse, pedicels shorter than the bracts, corolla scarcely 15 mm. long, and anther-sacs nearly glabrous.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: Keasbey; Long Beach; Forked River; Barnegat Pier; Beach Haven; Atlantic City; Ventnor; Mays Landing; Ocean City; Palermo; Sea Isle; Peermont; Cape May Court House (*2604*); Holly Beach; Five-mile Beach; Cold Spring (*2157*); Cape May.
Delaware: ——, *Bernhardi.*
Maryland: Ocean City.
Virginia: Parksley; Walnut Point.
North Carolina: Ocracoke Island; Beaufort.
Florida: Titusville; Eau Gallie; Marco; Sanibel; Pine Island; Tampa; Long Key, Pinellas Co.; Hernando Co.; St. Marks (*4702*); Apalachicola.
Alabama: Mobile Co.
Mississippi: Ship Island.
Louisiana: Breton Island.

3. AGALINIS PURPUREA (L.) Pennell, Bull. Torrey Club 40: 126. 1913

Gerardia purpurea L. Sp. Pl. 610. 1753. "Habitat in Virginia, Canada."
Anonymos purpurea (L.) Walt. Fl. Carol. 170. 1788.
Gerardia purpurea grandiflora Benth. in Hook. Comp. Bot. Mag. 1: 208. 1835–6. "New Jersey."
Agalinis palustris Raf. New Fl. Am. 2: 62. 1837. "Near marshes. . . . From New England to Carolina."
Agalinis longifolia Raf. New Fl. Am. 2: 62. 1836. "Near streams New Jersey to Virginia."
(?) *Agalinis corymbosa* Raf. New Fl. Am. 2: 63. 1837. "Carolina and Florida."

Flowers, mid-July to mid-October. Fruit, late-September to October.

DISTRIBUTION: Moist sandy soil, nearly throughout the coastal

plain. Abundant from New Jersey to South Carolina, in New Jersey in the middle district and coastal strip, absent from the New Jersey, probably also from the Wilmington, N. C., pine barrens; southward abundant near the coast in Georgia, extending to the Florida Keys, of occasional occurrence in the Altamaha grit region of Georgia, more common inland. Westward occasional, especially near the Gulf coast, and probably frequent north of the pine belts. A characteristic plant of coastal regions, edges of salt marshes. Widely distributed in the eastern United States, most abundant in the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: Keasbey; South River; Spotswood; Keyport; Farmingdale; New Egypt; Burlington; Delair; Griffith's Swamp; Kirkwood; South Westville; Clarksboro; Mickleton; Swedesboro; Deal; Belmar; Chadwick; Toms River; Seaside Park; Forked River; Waretown; Barnegat Pier; Cox's; Manahawken; Absecon; Atlantic City; Ventnor; Ocean City; Ocean City Junction; Avalon (*4004*); Wildwood; Middletown; Cape May Court House (*2602, 2603*); Bennett; Cape May.

Pennsylvania: Tinicum (*3598*).

Delaware: Porter; Ellendale; Rehoboth.

Maryland: Kent Island; Abbey's Island; Laurel; Lanham; Buena Vista (*2640*); College Park; Hyattsville; Bladensburg.

District of Columbia: Anacostia; Terra Cotta (*2678, 2679*); Holmead Swamp; District Line (*2639*); Washington.

Virginia: Alexander Island (*2671*); Arlington (*2672*); Alexandria; Four-mile Run; Seven Pines (*4946*); Smith's Island; Norfolk; Virginia Beach; Munden.

North Carolina: Weldon (*4948*); Rocky Mount (*4932*); Wilmington (*4914, 4927*); Southport.

South Carolina: Ebenezer; Santee Canal; Monks Corner (*4876*); Otranto (*4869*); Charleston; Yemassee (*4850, 4854*); Bluffton; Aiken.

Georgia: Thomson; Thalmann (*4811*); Waycross (*4784*); Fitzgerald; Naylor (*4746, 4753*); Thomasville (*4735A*); Cordele (*4769*); De Soto (*4758*); Leslie (*4767*).

Florida: Jacksonville (*4799*); San Pablo (*4806*); Miami; Black

Point; Homestead; Camp Longview; Long Prairie; Bull Key; Cape Florida; Fort Myers; Lakeland; St. Petersburg; Lake City; St. Marks (*4703*); Apalachicola.

Alabama: Mobile.

Mississippi: Ora; Long Beach; Pass Christian (*4357*).

4. AGALINIS VIRGATA Raf. New Fl. Am. 2: 62. 1837

Agalinis virgata Raf. "Glades of Pine woods in South New Jersey near Mullica Hill, &c." No type known to exist.

Gerardia racemulosa Pennell Torreya 11: 15. 1911. "Type.—Parkdale, Camden Co., N. J., *F. W. Pennell 2692* Coll. Sept. 27, 1910, in Herb. Acad. Nat. Sci. of Phila."

Flowers, September to mid-October. Fruit, mid-September to October.

DISTRIBUTION: In the coastal plain, New Jersey, and North and South Carolina. In New Jersey restricted to the pine barrens where frequent; frequent or common in the Wilmington pine barrens; frequent or occasional in pineland in South Carolina. Replaces *A. purpurea* in typical pine barrens. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: Hornerstown; Forked River; Pasadena; Atsion; Hammonton; Egg Harbor City; Parkdale (*2692, 2694, 3584, 3626, 3808*); Winslow Junction (in 1908).

North Carolina: Newbern; Wilmington (*4902, 4921*).

South Carolina: Monks Corner (*4877*); Eutawville; Charleston.

5. **Agalinis pinetorum** Pennell, sp. nov.

Annual. Plant 6–8 dm. tall, much branched, branches ascending, long and slender. Stem slightly angular, glabrous or nearly so. Leaves opposite, stiffly spreading, narrowly linear, thickened, very scabrous on the upper surface, those of the stem 2–2.5 cm. long. Axillary fascicles scarcely or not developed. Racemes of 8–14 mostly opposite flowers. Pedicels very short, in flower 2 mm. long or less, hardly longer in fruit. Calyx-lobes triangular-subulate, 1–1.5 mm. long. Corolla 20–25 mm. long, pubescent without, pubescent within at base of upper lobes, rose-purple, 2 yellow lines and purple spots within throat below; lobes all spread-

ing, rounded to emarginate, ciliate. Filaments lanose; anther-sacs oblong, lanose, minutely mucronate-awned at base, 2 mm. long. Style filiform 6–10 mm. long. Capsule globose, 5 mm. long. Seeds not seen.

Type, St. Marks, Wakulla Co., Florida, Sept. 26, 1912, *F. W. Pennell 4708*, in Herb. University of Pennsylvania.

Flowers, late-September to October.

DISTRIBUTION: Moist soil, in pineland, southern Georgia and northern Florida. Probably common in Altamaha grit region, frequent through flat pine woods of northern Florida, west to the Apalachicola River. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Waycross (*4781, 4791*); Douglas (*4775*); Naylor (*4750*); Thomasville (*4734, 4738*); Cordele (*4770, 4771, 4773*).
Florida: Jacksonville (*4795*); St. Marks (*4708*); Fort Gadsden (*4688*); Apalachicola.

6. **Agalinis delicatula** Pennell, sp. nov.

Annual. Plant 6–8 dm. tall, branched, branches long and very slender. Stem angular, glabrous. Leaves opposite, spreading, almost filiform, scabrous on the upper surface, those of the stem 1–2 cm. long. Axillary fascicles scarcely developed. Racemes of 8–12 mostly opposite flowers. Pedicels very short, in flower 2 mm. long or less. Calyx-lobes subulate, 1.5–2 mm. long. Corolla 20 mm. long, sparingly pubescent without, pubescent within at base of upper lobes, rose-purple, 2 yellow lines but (in this collection) no purple spots within throat below, lobes all spreading, rounded to emarginate, minutely ciliate. Filaments lanose; anther-sacs oblong, lanose, mucronate-awned at base, 1.5 mm. long. Style filiform. Fruit not seen.

Type, Ponce de Leon, Holmes Co., Florida, Sept. 17, 1912, *F. W. Pennell 4661* in Herb. University of Pennsylvania.

Nearest to *A. pinetorum* of which this may possibly prove a form, but the plants seen appeared strikingly distinct, and occurred in a different region, west of the known range of that species.

Flowers, mid-September to October.

DISTRIBUTION: Most sandy pineland, western Florida. Possibly frequent in the west Florida pine hills. Restricted to the coastal plain. Type only seen.

7. AGALINIS HARPERI Pennell in Small, Flora of Miami, 167. 1913

Agalinis Harperi Pennell. "Type.—St. Marks, Wakulla County, Florida. *F. W. Pennell*, 4707 coll. September 25, 1912" in Herb. University of Pennsylvania.

Annual. Plant 4–8 dm. tall, relatively sparingly branched. Stem slightly angular, glabrous or nearly so. Leaves opposite, rather stiffly spreading, narrowly linear, scabrous on the upper surface, those of the stem 2–3.5 cm. long. Axillary fascicles scarcely or not developed. Racemes of 8–20 mostly opposite flowers. Pedicels very short, in flower less than 2 mm. long, hardly longer in fruit. Calyx-lobes triangular-lanceolate to triangular-subulate, 1 mm. long or less. Corolla 15–18 mm. long, pubescent without, pubescent at base of upper lobes within, pink-purple, 2 yellow lines within throat below, small purple spots mostly along these; lobes all spreading, rounded to truncate, ciliate. Filaments lanose; anther-sacs oblong, lanose, acute at base, 1.5 mm. long. Capsule 4–5 mm. long. Seeds reticulated with dark brown ridges, areas between these relatively dark, with finer cross lines.

Flowers, mid-September to mid-October. Fruit, October.

DISTRIBUTION: Moist sandy pineland, borders of salt marsh, etc. Flat pine woods of southern Georgia, south through the Florida peninsula. Apparently most frequent in the Everglades. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Thalmann (*4810*); Thomasville (*4726*).
Florida: Camp Longview; St. Marks (*4701, 4707, 4711*).

8. AGALINIS FASCICULATA (Ell.) Raf. New Fl. Am. 2: 63. 1837

Gerardia fasciculata Ell. Sketch 2: 115. 1824. "Grows principally in lands subject to occasional inundation from the ocean—on Eding's Island near Beaufort very common."

Type seen in the Elliott Herbarium at the Charleston Museum.

Gerardia purpurea fasciculata (Ell.) Chapm. Fl. So. U. S. 300. 1860.

Flowers, August to October. Fruit, September to October.

DISTRIBUTION: Moist to dry sandy, loam, or clay soil; depressions among sand-dunes of beach, edges of salt marsh, or loam soil

in limestone districts, etc.; especially in old fields, almost the only *Agalinis* to be met with in cultivated soil. In the coastal plain, Norfolk Co., Virginia (where perhaps introduced); South Carolina to Louisiana, mostly near the coast. Common near the coast in South Carolina and Georgia, and apparently through most of the Florida peninsula. Apparently absent or rare in Altamaha grit region, west Florida pine hills, or inland from the coast in Alabama. In clay soil in Georgia north of the Altamaha grit. Near the coast westward to Louisiana. Abundant in alluvial districts near the lower Mississippi River, and in the hill country of West Feliciana Parish. Extending westward to Texas, and north through the lower Mississippi Valley. Casually introduced on ballast at Philadelphia.

PLANTS AND SPECIMENS EXAMINED:

Virginia: Northwest.

South Carolina: Santee Canal; St. Johns; Otranto (*4868*); Sullivan's Island (*4860*); Charleston (*4863*); Edisto Island; Aiken; Yemassee (*4849*); Beaufort; Hilton Head; Bluffton; Goat Island.

Georgia: Brunswick (*4818*); Cumberland Island; Waycross (*4792*); Naylor (*4747, 4751*); Valdosta (*4740*); Thomasville (*4735*); Cordele (*4755, 4772*); Leslie (*4761, 4766*).

Florida: Jacksonville (*4793*); St. Augustine; Orange City; Eustis; Minneola; Clarcona; Killarney; Merritt's Island; Fort Lauderdale; Miami, Alapattah; Cocoanut Grove; Homestead; Biscayne Bay; Big Pine Key; Sanibel; Polk Co.; Tampa; St. Petersburg; Fort King; Gainesville; Lake City; Monticello (*4718*); St. Marks (*4706, 4717*); Tallahassee (*4695, 4697*); River Junction (*4669*); Apalachicola (*4675, 4680*).

Alabama: Mobile; Cedar Point.

Mississippi: Ocean Springs; Biloxi (*4370*); Pass Christian (*4356*); Natchez.

Louisiana: Mandeville; Covington; Amite City; Hammond; Slaughter (*4267*); Baines (*4276*); Catalpa (*4303, 4304, 4330*).

9. **Agalinis georgiana** (C. L. Boynton) Pennell, comb. nov.

Gerardia georgiana C. L. Boynton in Biltm. Bot. Stud. 1: 148. 1902. "In the pine barrens near Cordele, Dooly County,

Georgia, in September, 1901. . . . in moist sandy soil in pine barrens. . . . The type specimens are deposited in the Biltmore Herbarium." Type, collected Sept. 18, 1901, seen in the Biltmore Herbarium.

Flowers, mid- to late-September. Fruit, late-September to October.

DISTRIBUTION: Dry sandy or clay soil, in pineland. Southern Georgia, southern Alabama, and northern Florida. Apparently occasional in flat pine woods of southern Georgia and northern Florida; near Cordele, Georgia; frequent in pine hills of western Florida and southeastern Alabama. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Valdosta (*4739*); Thomasville (*4728*); Dooly Co.
Florida: Fort Gadsden (*4693*); Chipley (*4665*); Ponce de Leon (*4662*); Milligan (*4586*).
Alabama: McRae (*4609*); Florala (*4629, 4632*).

10. **Agalinis pulchella** Pennell, sp. nov.

Annual. Plant 6–10 dm. tall, widely branching. Stem angular, scabrous. Leaves spreading, linear, scabrous on the upper surface, those of the stem opposite, 2–3 cm. long. Axillary fascicles conspicuously developed, but mostly shorter than the leaves. Racemes of 4–6 mostly alternate flowers, uppermost one, by arresting of stem-apex, often suggesting a terminal flower. Pedicels slender, in flower 15–30 mm., in fruit 25–40 mm. long, much longer than the bracts. Calyx-lobes minute, less than .5 mm. long, subulate. Corolla 25–30 mm. long, minutely pubescent without, pubescent within at base of upper lobes, rose-purple, 2 yellow lines and relatively large purple spots within throat below; lobes all spreading (upper much reflexed), notched at apex, ciliate. Filaments lanose; anther-sacs ovate, evidently short-awned, densely wooly over entire surface, 3 mm. long. Style slender, 10–20 mm. long. Capsule globose, 5–6 mm. long. Seeds reticulated, with dark-brown ridges, areas between these more or less broadly hexagonal, pale, not finely reticulated.

Type, Ponce de Leon, Holmes Co., Florida, Sept. 17, 1912, *F. W. Pennell 4658*, in Herb. University of Pennsylvania.

Flowers, September. Fruit, October.

DISTRIBUTION: Dry open, sandy pineland, southern Georgia, and northern Florida, westward to Louisiana. Frequent in the Altamaha grit region of Georgia, the flat pine woods southward to the Gulf coast in northern Florida, through the pine hills of western Florida and southeastern Alabama, and in Mobile Co., Alabama. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Waycross (*4779*); Douglas (*4776*); Moultrie; Thomasville (*4731*); Cordele.

Florida: Gadsden Co.; Fort Gadsden (*4692*); Chipley (*4650*, *4663*); Ponce de Leon (*4658*); Milligan (*4587*).

Alabama: McRae (*4642*); Theodore (*4427*, *4452*, *4454*, *4455*, *4493*, *4515*).

11. AGALINIS FILIFOLIA (Nutt.) Raf. New Fl. Am. 2: 65. 1837

Gerardia filifolia Nutt. Gen. Pl. N. Am. 2: 48. 1818. "HAB. In West Florida. Dr. Baldwyn." No type in Herb. Acad. Nat. Sci. Philadelphia.

Flowers, September to early-October. Fruit, October.

DISTRIBUTION: Rather dry, sandy pineland, southern Georgia and Florida. Frequent or common in flat pine woods of southern Georgia and northern Florida, south through the Florida peninsula to Miami, west to Apalachicola, and along the coast to Santa Rosa Island, possibly reaching extreme southern Alabama. Plant from Santa Rosa Island, remarkably fleshy, possibly in brackish situation.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Sunbury; Brunswick (*4821*, *4828*); Waycross (*4785*); Naylor (*4752*); Valdosta (*4741*).

Florida: Jacksonville (*4800*); South Jacksonville; St. Nicholas; San Pablo (*4803*); Mayport; Pablo Beach; St. Augustine; Clarcona; Tillman; Miami; Manatee; Fort Gadsden (*4694*); Apalachicola (*4671*, *4673*); St. Vincent; Santa Rosa Island.

Alabama: ——, *Gates* (probably really from Florida.)

12. **Agalinis Holmiana** (Greene) Pennell, comb. nov.

Gerardia Holmiana Greene, Pittonia 4: 52. 1899. "Plentiful in open pine and oak groves along Michigan Avenue south of

the Soldiers' Home grounds near Brookland, D. C., collected by Mr. Holm and the writer, 20 Oct., 1898." No specimen of this date seen, but one in Herb. N. Y. Bot. Gard., of Dr. Greene's collecting, from Brookland, D. C., dated Oct. 16, 1898, may stand as the type.

Flowers, late-August to mid-October. Fruit, mid-September to October.

DISTRIBUTION: Dry sandy pineland. Long Island to Florida and Alabama; irregularly distributed. Common in the pine barrens of New Jersey, sparingly in the middle district of the same state; common on the Potomac formation between Baltimore and Washington; common in Wilmington pine barrens of southeastern North Carolina, and probably so near the coast to Charleston, South Carolina; inland probably in the fall line sand hills through South Carolina and Georgia, apparently into Alabama; at Tampa, Florida. Rather narrower-leaved and more setaceous in true pine barrens. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: South River; Spotswood; Freehold; Tomlin; Franklinville; Pasadena; Woodmansie; Jackson; Atco (*3544*, *3628*); Malaga; Egg Harbor City; Absecon.

Maryland: Glen Burnie; Riverdale; Lanham; Cherry Grove (*2644*); Sligo Mill Road (*2657*); Oxon Hill.

District of Columbia: Takoma (*2655*); Lamond (*2656*); Terra Cotta (*2680*); Brookland (*2662*, *2669*); Washington.

North Carolina: Newbern; Wilmington (*4904*, *4923*, *4929*); Fayetteville.

South Carolina: Columbia; Charleston (*4864*); Aiken.

Georgia: Augusta; Burke Co.; Butler.

Florida: Tampa.

Alabama: ——, *Meisner*(?).

13. AGALINIS SETACEA (Walt.) Raf. New Fl. Am. 2: 64. 1837

Anonymos setacea Walt. Fl. Carol. 170. 1788. No type locality given, presumably should be from South Carolina, but apparently from farther west. Type in the British Museum identified by Dr. A. B. Rendle as agreeing with my number *4757*.

Gerardia setacea (Walt.) J. F. Gmel. *curante* L. Syst. Nat. ed. 13. 927. 1791.

Gerardia Plukenetii Ell. Sketch 2: 114. 1824. "Grows in wet spungy soils, very common between the Oakmulgee and Chatahouchie Rivers." Type seen in the Elliott Herbarium at the Charleston Museum. Statement of habitat probably due to confusion with *Agalinis pinetorum* Pennell.

Agalinis Plukenetii (Ell.) Raf. New Fl. Am. 2: 63. 1837.

Agalinis setacea (Walt.) Raf. As to synonymy, not description, the latter probably applying to *A. erecta* (Walt.) Pennell.

Gerardia filifolia Gatesii Benth. in DC. Prodr. 10: 518. 1846. "In Alabama (Gates!)." Type in the Kew Herbarium, identified, from fragment sent me, as this species.

Flowers, mid-September to October. Fruit, not seen, probably late-October to November.

DISTRIBUTION: Dry open sandy pineland. In the coastal plain from western Georgia and northern Florida to eastern Mississippi. Frequent from Sumter County, Georgia, westward through the pine hills of western Florida and southern Alabama to southeastern Mississippi, abundant toward the coast. One record from the Florida Keys,—Pine Key, *Blodgett*—likely due to mixing of labels. Occasional above the fall line in northern Alabama and northern Georgia.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Cobb (*4757*); Cuthbert.

Florida: Apalachicola (*4672*); Milligan (*4583, 4584*); Milton (*4569, 4570*).

Alabama: Auburn; Wright's Mill; Tuskegee; Clayton; Florala (*4623*); Bay Minette (*4561*); Mobile; Spring Hill (*4524*); Crichton (*4523*); Theodore (*4426, 4457, 4461, 4517*).

Mississippi: Meridian; Biloxi (*4382*).

14. **Agalinis laxa** Pennell, sp. nov.

Annual. Plant 6–10 dm. tall, widely and very laxly branched. Stem nearly terete below, slightly angled above, glabrous. Leaves spreading, opposite nearly throughout, narrowly linear to nearly filiform, nearly glabrous, those of the stem 2–3 cm. long. Axillary fascicles scarcely or not developed. Racemes of 3–8 mostly

opposite flowers. Pedicels in flower 15–30 mm., in fruit 25–50 mm. long, 4–5 times exceeding the bracts. Calyx-lobes minute, less than 0.5 mm. long, acute. Corolla 15–18 mm. long, minutely pubescent without, pubescent with pink hairs within at base of upper lobes, pink-purple, 2 yellow lines, and small purple spots especially along these, within throat; lobes all spreading, rounded, ciliate with pink hairs. Filaments sparingly lanose, upper shorter pair nearly glabrous; anther-sacs ovate, mucronate at base, pale, lanose, 1.5 mm. long. Style 4–5 mm. long. Capsule globose-ovoid, 4–5 mm. long. Seeds nearly black, small for the genus, with relatively heavy longitudinal and connecting ridges.

Type, Brunswick, Glynn Co., Georgia, Oct. 10, 1912, *F. W. Pennell 4824*, in Herb. University of Pennsylvania.

Flowers, late-September to October. Fruit, late-October.

DISTRIBUTION: Dry sandy pineland, river sand hills and old dunes, near the coast, South Carolina to Florida. Frequent from Brunswick, Georgia to Jacksonville, Florida; no specimens seen from farther south on Atlantic Coast. One specimen from Hernando County, Florida. Probably frequent on river sand hills in lower Georgia and northeastern Florida. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

South Carolina: Monks Corner (*4880*).
Georgia: Brunswick (*4824*); Bonnyman (*4778*); Waycross (*4783*).
Florida: Jacksonville; San Pablo (*4805*); Pablo Beach (*4801*); Hernando Co.

15. **Agalinis oligophylla** Pennell, nom. nov.

Gerardia Plukenetii microphylla A. Gray, Syn. Fl. N. Amer. II. 1: 293. 1878. "Louisiana, *Drummond*, *Hale*. Keys of Florida, *Blodgett*, &c." Louisiana material to be counted as typical. I have not seen the type. For Florida citation see under *Agalinis setacea* (Walt.) Raf.

Gerardia microphylla (A. Gray) Small, Fl. S. E. U. S. 1077. 1338. 1903; not *Agalinis microphylla* Raf. New Fl. Am. 2: 65. 1837.

DISTRIBUTION: Probably moist pineland, southern Louisiana, east of the Mississippi River at Jackson, East Feliciana Parish, more frequent westward. One old specimen seen labeled, probably incorrectly, as from Alabama. Restricted to the coastal plain.

SPECIMENS EXAMINED:

(?) Alabama: ——, *J. Torrey.*
Louisiana: Jackson.

16. AGALINIS APHYLLA (Nutt.) Raf. New Fl. Am. 2: 65. 1837

Gerardia aphylla Nutt. Gen. Plant. N. Am. 2: 47. 1818. "HAB. From North Carolina to Florida, where it was first detected by Dr. Baldwyn." Type seen in Herb. Acad. Nat. Sci. Philadelphia; accompanied by fruiting plant of *Agalinis erecta* (Walt.) Pennell.

Gerardia aphylla grandiflora Benth.* in Hook. Comp. Bot Mag. 1: 174. 1835–6. "Jacksonville." *Drummond.*

Agalinis microphylla Raf. New Fl. Am. 2: 65. 1837. "In Florida, collected by Leconte (Collins herb.)."

Flowers, mid-September to early November. Fruit, October to November.

DISTRIBUTION: Moist sandy pineland near the coast, North Carolina to Florida and Louisiana. Occasional from the Wilmington pine barrens southward, through North and South Carolina; most abundant in the flat pine woods of southern Georgia and northern Florida, frequent in the Altamaha grit region of Georgia; the west Florida pine hills; less frequent westward to Louisiana. Apparently does not occur in the Florida peninsula. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

North Carolina: Wilmington.
South Carolina: Santee Canal.
Georgia: Thalmann (*4808*); Brunswick (*4819*); Waycross (*4789*); Coffee Co.; Naylor (*4748*).
Florida: Tisonia (*4814*); Jacksonville (*4798*); South Jacksonville; St. Marks (*4712*); Fort Gadsden (*4682*); Apalachicola (*4676*); Chipley (*4647, 4664*); Point Washington; Ponce de Leon (*4655*); Milligan.
Alabama: Mobile; Spring Hill.

* Dr. N. E. Brown has kindly consulted the Bentham correspondence at Kew, which makes it evident that this author is responsible for the treatment of *Gerardia* in Hooker's account of the plants of Drummond's collections. Also it seems evident that the paper containing this was not published until early in 1836.

Mississippi: Ocean Springs; Biloxi; Pass Christian; Nicholson.
Louisiana: Abita Springs.

17. **Agalinis decemloba** (Greene) Pennell, comb. nov.

Gerardia decemloba Greene, Pittonia 4: 51. 1899. "Plant not uncommon about Brookland, D. C., inhabiting grassy knolls and hillsides bordering on pine woods." A specimen in Herb. N. Y. Bot. Gard. collected by Dr. E. L. Greene at Brookland, D. C., in Oct. 1898, may stand as the type.

Flowers, late-August to mid-September. Fruit, late-September to October.

DISTRIBUTION: Dry soil, light sand or clay, in the coastal plain in Kent Co., Delaware, frequent on Potomac formation near Washington, D. C., and probably occasional south to North Carolina. Occasional inland in the Piedmont region from Pennsylvania to North Carolina. Apparently has a fragmentary distribution, but not well understood.

PLANTS AND SPECIMENS EXAMINED:

Delaware: Felton.
Maryland: Buena Vista (*2641*); Lanham; Forest Glen; Silver Springs.
District of Columbia: Takoma Park (*2654*); Brookland (*2660, 2661, 2677, 4950*).

18. **Agalinis tenella** Pennell, sp. nov.

Annual. Plant 5–8 dm. tall, laxly branched, branches slender. Stem angled, glabrous throughout. Leaves spreading, linear-filiform to nearly filiform, acutish to acute, opposite nearly throughout, those of the stem 1–1.5 (– 2) cm. long. Axillary fascicles none. Racemes of 8–12 mostly opposite flowers. Pedicels slender, in flower 8–20 mm. long, in fruit reaching 25 mm. long. Calyx-tube reticulate-venulose; lobes minute, apiculate. Corolla 15–20 mm. long, minutely pubescent without, pubescent with pink hairs within at base of upper lobes, rose-pink, 2 yellow lines and small diffused purple spots within throat; lobes all spreading, more or less emarginate, ciliate. Filaments lanose especially toward apex; anther-sacs lanceolate, mucronate at base, 2 mm. long, villose with pink hairs 1.5 mm. long. Style slender, 5–8 mm. long. Capsule globose-ovoid, much flattened at base, 4 mm. long. Seeds narrow, yellowish-brown.

Type, Thomasville, Thomas Co., Georgia, Sept. 28, 1912, *F. W. Pennell 4727*, in Herb. University of Pennsylvania.

Flowers, mid-September to mid-October. Fruit, October.

DISTRIBUTION: Dry sandy pineland, in the coastal plain from South Carolina to Florida and Alabama. Occasional in lower South Carolina; most abundant in Altamaha grit region of Georgia; less frequent in upper edge of flat pine woods of southern Georgia entering north central Florida at Gadsden County, and in middle Georgia entering east central Alabama at Lee County. In the Altamaha grit region common, mostly replacing *A. erecta* Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

South Carolina: Otranto (*4871*); Eutawville; Yemassee (*4853*).
Georgia: Waycross (*4782, 4786*); Naylor (*4744*); Douglas (*4777*); Moultrie; Thomasville (*4727*); Cordele (*4768, 4774*); Cobb (*4756*); Leslie (*4764*).
Florida: Chattahoochie.
Alabama: Auburn.

19. AGALINIS ERECTA (Walt.) Pennell, in Small, Fl. Florida Keys, 133. 1913

Anonymos erecta Walt. Fl. Carol. 170. 1788. No type locality given, presumably from Berkeley County, South Carolina. There is no type in the Walter collection in the British Museum. Of the species occurring in Berkeley County, those which best answer the description are *Agalinis Holmiana* (Greene) Pennell, *Agalinis laxa* Pennell, and the following. Of these the first two are long-pediceled, and very lax, the bracts in the first are scarcely conspicuously shorter than the peduncles, moreover both are relatively infrequent. The third species, the following, in its strict erect habit, its pedicels not conspicuously long, but with bracts conspicuously shorter, seems seems best to fit Walter's description; moreover, it appears to be much the most abundant species of the district.

Gerardia erecta (Walt.) J. F. Gmel. *curante* Linn. Syst. Nat. ed. 13, 928. 1791.

Gerardia setacea parvifolia Benth.* in Hook. Comp. Bot. Mag. 1: 174. 1835–6. "Jacksonville." *Drummond.*

Agalinis obtusifolia Raf. New Fl. Am. 2: 64. 1837. "West Tennessee, Alabama and Florida." Description in greater part or entirely of this species, though the Tennessee specimen could hardly belong here.

Gerardia parvifolia (Benth.) Chapm. Fl. So. U. S. 300. 1860.

Agalinis parvifolia (Benth.) Small in Britt. & Br. Ill. Fl. ed. 2. 3: 212. 1913.

Flowers, early-September to mid-October. Fruit, October.

DISTRIBUTION: Moist to dry sandy pinelands, in the coastal plain from North Carolina to Florida and Louisiana. Occasional or frequent in eastern North Carolina; common in the Wilmington pine barrens, and southward near the coast to Charleston, South Carolina; less frequent in the Altamaha grit region and inland in Georgia; common through the flat pine woods of Florida, south through the peninsula and on the Florida Keys; common westward through the pine hills of west Florida, decreasing inland in southeastern Alabama; and common near the Gulf coast westward to eastern Louisiana. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

North Carolina: Rocky Mount (*4933*); Wilmington (*4910*, *4915*, *4926*); Brunswick Co.

South Carolina: Monks Corner (*4879*); Otranto (*4870*).

Georgia: Sunbury; Coffee Co.; Moultrie; Thomasville (*4733*); Leslie.

Florida: Tisonia (*4815*); Jacksonville (*4797*); San Pablo (*4804*); Green Cove Springs; St. Augustine; Big Pine Key; Marco; Fort Myers; Polk Co.; Tampa; Lake City; St. Marks (*4710*); Fort Gadsden (*4685*); Apalachicola; Chipley (*4646*, *4667*); Ponce de Leon (*4659*); Paxton (*4640*); De Funiak Springs; Milligan (*4596*).

Alabama: McRae (*4614*); Florala (*4634*); Bay Minette (*4548*, *4562*); Mobile; Spring Hill (*4526*); Theodore (*4428*, *4453*); Hollander's Island (*4503*).

Mississippi: Waynesboro; Ocean Springs; Biloxi (*4399*); Manuel; Gulfport; Long Beach; Pass Christian (*4363*); Nicholson.

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*See footnote on page 433.

Louisiana: Pearl River; Bayou Lacombe; Abita Springs (*4226*, *4227*, *4231*).

20. AGALINIS TENUIFOLIA (Vahl.) Raf. New Fl. Am. 2: 64. 1837

Gerardia tenuifolia Vahl, Symb. Bot. 3: 79. 1794. "Habitat in America septentrionali." Type in Herb. Universitetets botaniske Museum, Copenhagen, Denmark, collected by Von Rohren, and said to be probably from Philadelphia, is identified by Dr. C. H. Ostenfeld as agreeing with material (my number 2681) sent from eastern Pennsylvania.

Flowers, mid-August to mid-October.

DISTRIBUTION: Moist to dry sand or loam, deciduous or mixed woodland, widely distributed and common through the eastern United States above the fall line, in the coastal plain locally frequent, especially in limestone districts. In New Jersey occasional in the middle and Cape May districts, occasional southward near the fall line; in Sumter County, Georgia; frequent in red loam soil in central northern Florida; in limestone in southeastern Alabama and western Florida; and in alluvial soil in southern Alabama and Louisiana. A larger plant southward.

PLANTS AND SPECIMENS EXAMINED:

New Jersey: New Egypt; Camden; Clarksboro; Swedesboro; Bennett; Cold Spring.
Delaware: Van Dyke.
Maryland: Ardwick (*2645*); Oxon Hill.
District of Columbia: Brookland (*2658*).
Georgia: De Soto (*4759*); Leslie.
Florida: Monticello (*4721*); Tallahassee (*4699*); Chattahoochie; River Junction (*4670*); Aspalaga; Paxton (*4601*).
Alabama: Chapel Hill, Covington Co. (*4619*); Florala (*4597*, *4606*); Cocoa; Mobile; Crichton (*4522*).
Mississippi: Meridian; Jackson.
Louisiana: Mandeville(?); Catalpa.

21. **Agalinis divaricata** (Chapm.) Pennell, comb. nov.

Gerardia divaricata Chapm. Fl. So. U. S. 299. Mar. 26, 1860. "Low sandy pine barrens." No type indicated, but abundant

material of this species collected and distributed by the describer.

Gerardia Mettaueri Wood, Class Book 530, Dec. 1, 1860. "Wet sandy places, Middle Fla. (Dr. Mettauer)." Type seen in Herb. Columbia University.

Gerardia Mettaueri clausa Wood, Class Book 530, Dec. 1, 1860. "With the others," i. e. the species and *G. Mettaueri nuda Chapm.*

Flowers, September to October. Fruit not seen.

DISTRIBUTION: Dry sandy pineland, western Florida and adjacent southeastern Alabama. Abundant through the west Florida pine hills, eastward through the middle Florida flat woods to Apalachee Bay. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Florida: St. Marks (*4716*); near Tallahassee; Gadsden Co.; Carrabelle; Fort Gadsden (*4684, 4687*); Apalachicola (*4679*); Chipley (*4644, 4668*); Ponce de Leon (*4657*); Portland; Milligan (*4593*); Milton (*4572*).
Alabama: Florala (*4622, 4624, 4627, 4633*).

22. **Agalinis filicaulis** (Benth.) Pennell, comb. nov.

Gerardia aphylla filicaulis Benth.* in Hook. Comp. Bot. Mag. 1: 174. 1835. "Jacksonville." *Drummond.*

Gerardia filicaulis (Benth.) Chapm. Fl. So. U. S. 299. Mar. 26, 1860.

Gerardia Mettuaeri nuda Wood, Class Book 530, Dec. 1, 1860. Under *Gerardia nuda* Wood (1870), "Middle Fl. (Dr. Mettauer, 1855)."

Gerardia nuda Wood, Am. Bot. and Flor. 231. 1870.

Flowers, mid-September to early November. Fruit, October to November.

DISTRIBUTION: Moist grassy sandy pineland, in the coastal plain from southern Georgia and northern Florida to eastern Louisiana. Frequent in the flat pine woods of southern Georgia and northern Florida; occasional or rare in the Altamaha grit region; frequent in the pine hills of western Florida and adjacent

* See footnote on page 433.

southeastern Alabama; westward near the coast to southern Mississippi and probably eastern Louisiana. Restricted to the coastal plain.

PLANTS AND SPECIMENS EXAMINED:

Georgia: Waycross (*4788*); Naylor (*4749*); Tyty.

Florida: Jacksonville (*4796*); St. Marks (*4709*); Fort Gadsden (*4689*); Apalachicola (*4677*); Ponce de Leon (*4660*); Paxton (*4643*); De Funiak Springs; Milligan (*4594*).

Alabama: McRae (*4608*); Florala (*4626*).

Mississippi: Ocean Springs; Biloxi; Pass Christian.

Louisiana: "New Orleans." *T. Drummond.*

UNIVERSITY OF PENNSYLVANIA.

Some observations concerning the reactions of the leaf hairs of Salvinia natans

FRANK MARION ANDREWS AND MAX MAPES ELLIS

If one observes plants of *Salvinia natans* which are in an active condition, it will be observed that the hairs on the leaves show drops of liquid which they secrete. It was noticed from time to time that some of the leaves of the *Salvinia* which was kept growing in a large tub in the green-house bore small drops of dark colored liquid. Frequently a dead dipterous insect was found on the surface of a leaf somewhat enveloped in a white fungus which was also attached to the leaf hairs. These occurrences coupled with the superficial resemblance of the leaves of *Salvinia* to those of *Drosera* suggested the possibility that this fern might also be able to absorb food from decaying matter on the leaves. It was first desirable to see if organic matter would go into solution on the leaves of this plant.

Experiment 1. Two large battery jars of *Salvinia* were isolated from the tub and small soft-bodied dipterous and thysanuran insects, such as were found in and about the tub, were crushed and placed upon many of the leaves. By the end of a week all of these insects were covered with a white fungus, apparently the same as that previously noted on the *Salvinia* in the tub. During the second week almost all of this fungus disappeared and most of the insects were reduced to drops of dark colored liquid. Only a few of the insects dried up. This experiment makes it entirely probable that some of the dark colored drops found on the leaves of the *Salvinia* in the tub contained organic remains. This reduction of the organic matter to a solution may have been the result of any or all of these three actions, (1) simple decomposition, (2) action by the *Salvinia* or (3) action by the fungus. Three experiments were made to ascertain whether or not the *Salvinia* contributes to this decomposition of the organic matter.

Experiment 2. Several large crystallizing dishes were filled with fresh *Salvinia*. On the surface of about every other leaf

was placed a small piece, approximately one millimeter cube, of the white of a hard boiled egg. The weight of the cubes was not great enough to break down the leaf hairs on which they rested. Similar cubes of the boiled white of egg were placed on clean glass in the dishes just above the surface of the water, as controls. During the first twenty-four hours all of the white of egg, both control and experiment, became rather transparent. At the end of forty-eight hours several of the leaves were removed and examined under a microscope. The cubes of egg had retained their shape perfectly, that is, there had been no rounding off of the edges as has been previously noted in the digestion of the white of egg by *Drosera*. A certain amount of the white of egg had been removed, however. Each of the leaf hairs on which the cube was resting had penetrated it and reached nearly through the block of boiled egg. The extreme tips of the prongs of each hair were thus firmly imbedded in the white of egg, but the remainder of the leaf hair scarcely touched the cube, being smaller than the chamber it occupied. This little chamber resembled a hole made in ice with a warm metal rod, being slightly larger than the leaf hair at every point except the tip. In addition to this reaction by the leaf hairs supporting the cube of white of egg, the row of hairs immediately around the cube which were not under it but which just touched it had also reacted. These hairs had bent in on all sides, penetrating the cube of white of egg in the same manner as those hairs on which the cube was resting, except that they entered the cube from the side; that is, there seemed to have been a positive chemotaxis on the part of the leaf hairs with reference to the white of egg. This experiment was continued for several days, with many plants and always with the result as just stated. Special precaution was necessary to keep the cubes of boiled egg from drying out too quickly. However, the white of egg did not injure the leaves in any way as far as could be determined during the six days it rested on them.

Experiment 3. Other cultures of *Salvinia* were isolated and small drops of *uncooked* white of egg placed on most of the leaves. Control drops of water of the same size were also placed on many leaves. The drops of both white of egg and water rested as tiny spheres on top of the leaf hairs for the first twenty-four hours.

During the second twenty-four hours the drops of white of egg in many instances broke, forming irregular patches which sank down to the surface of the leaf, completely surrounding the hairs which had supported them. At the same time the neighboring leaf hairs bent over into the white of egg in much the same manner as noted regarding the cubes of cooked white of egg. The control drops of water did not change meanwhile, remaining as spheres on top of the leaf hairs. Several things might have caused the drops of white of egg to act in this manner, but in the light of the solvent action of the leaf hairs on the cubes of cooked white of egg it seems probable that the leaf hairs themselves were responsible for the change which caused these drops of raw white of egg to change. These cultures were continued for eight days. During this time several of the drops of white of egg became infected with the white fungus already mentioned. The result was the same as that with the crushed insects. The white of egg became steadily more liquid until it was reduced to a fluid almost as mobile as water. By close observation it could be determined that in those cases where the tiny spheres of white of egg did not break and run down on to the surface of the leaf the amount of white of egg had decreased.

Experiment 4. On the leaves of fresh cultures of *Salvinia* drops of *uncooked* yellow of egg were placed. Controls were established by drops of the yellow of the egg being placed on clean glass in the dishes with the *Salvinia*, just above the surface of the water. The color of the egg on the leaves became noticeably paler than the control during the first twenty-four hours. At the end of forty-eight hours it had spread over a small area of the leaf surface in the same manner as the uncooked white of egg had done in the previous experiment. The color of this egg on the leaves was several shades lighter than the control and of a quite different consistency, being more like cream than the control. The same chemotaxis was displayed by the hairs surrounding the area covered by the egg.

Experiment 5. It was the object of this experiment to ascertain whether the plant was profiting by the presence of the decaying or soluble organic matter on the surface of its leaves. Four different jars of *Salvinia* were prepared.

In jar Number 1 the *Salvinia* was floated on distilled water.

In jar Number 2 on a nutrient solution containing the following substances:

Distilled water	1000.0 cc.
Potassium nitrate	1.0 gm.
Calcium sulphate	0.5 gm.
Magnesium sulphate	0.5 gm.
Sodium phosphate	0.5 gm.

Jar Number 3 contained a nutrient solution the same as that used in Number 2, except that the potassium nitrate was omitted. On the leaves of the *Salvinia* in this jar were placed cubes of cooked white of egg, drops of uncooked white of egg and crushed insects.

Jar Number 4 also contained a nutrient solution the same as Number 3, that is, without the potassium nitrate, but the leaves in this jar were free from foreign substances.

The *Salvinia* in jar Number 1 began to change color on the second day. The otherwise bright green color of the leaves became dull and by the fifth day there were distinct yellow spots on the leaves. In a week all of the leaves in this jar were of a uniform brownish-yellow color. In *Salvinia* care must be taken to keep the light conditions for good growth as nearly constant as possible. It frequently happens that *Salvinia* plants that have been growing in somewhat weak light will, when brought into very bright light, lose their green color and die. This, however, may be prevented by gradually bringing them into strong light which they may then stand without the least injury.

The plants in jar Number 2 remained quite normal throughout the entire experiment, which lasted fifteen days.

The leaves in jar Number 3 began to lose their color in six days and those in Number 4 four days. Both those with and without foreign matter on them finally lost all their color. By the end of the first week, however, there was a decided difference between the leaves in the two jars. Almost all of the leaves in both jars were turning yellow but those in jar Number 3 retained their color, especially, in the area immediately around that covered with organic matter. The ninth day all the leaves in both jars were yellow, excepting a few in jar Number 3. These few were still a little green in the area around the organic matter.

They continued to fade and by the fifteenth day all were entirely yellow.

This experiment shows that the plant can obtain a certain quantity of its food from the decomposing organic matter offered to it in the way above described. The amount that can be taken up by the leaf hairs, however, is small and is insufficient to supply the demands of the plant. The *Salvinia* with organic matter on its leaves seemed to have an advantage but this advantage in nature is only occasional or as chance offers.

Experiment 6. Pieces of cinder and iron filings were carefully laid on the leaves and allowed to remain for several days. No reaction of any sort occurred among the hairs of the leaves.

SUMMARY

One of the most interesting results was the chemotactic reaction of the leaf hairs. This was very distinct in every case, excepting experiment 6.

The experiments proved that the leaf hairs are capable of exerting a distinct solvent action on the organic matter placed on them. Experiments 2, 3 and 4 show this. This solvent action does not serve to remove any objectionable organic matter but the plant profits by the food derived by this action. The latter is well shown from the observations made, especially those of experiment 5. No experiment showed the leaves suffering from the presence of small amounts of organic matter on their leaves and on the contrary the leaves thus treated were the last to lose the green color as in experiment 5. The *Salvinia* may get only a small quantity of food in this way, as is indicated by the rapid decline of the plants even in experiment 5 when placed in a solution free of potassium nitrate. The positive chemotaxis of the leaf hairs, the solvent action on the cubes of cooked white of egg and the discoloring of the yellow of the raw egg coupled with the fact that in the normal habitat this fern frequently has the bodies of small soft insects which are finally dissolved on its leaves, shows at least that some food is taken in by these leaves when it is offered.

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On the relationship between the number of ovules formed and the capacity of the ovary for maturing its ovules into seeds

J. Arthur Harris

I. Introductory Remarks

In a series of papers published in part only and which need not be cited here, I have attempted by the use of the modern higher statistics to analyze the internal factors influencing seed production.

This work has consisted chiefly in determining the correlations between the degree of development of various somatic organs and the fertility of the fruit.

Certain peculiarities of the fruit itself have been also considered in their relationship to capacity for seed production or to the characteristics of the seed formed. A question of considerable interest upon which very little has been published is that of the relationship between the number of ovules formed by a fruit and its capacity for maturing these ovules into seeds. To the data of this problem the present paper is a contribution. In it only questions of fact will be considered, for it is quite premature to essay any interpretation of observed relationships in more general terms.

The problem in hand is to determine whether ovaries with a number of ovules above the average are more (or less) capable of developing their ovules into seeds than those below the average. *A priori*, ovaries with more than the mean number of ovules must be expected to produce on the average absolutely more seeds than those with less than the mean number. *A posteriori*, this condition is found almost without exception. But the question which interests the physiologist is whether ovaries of any class with respect to number of ovules are more capable of seed production as shown by their developing a higher proportion of their ovules into seeds.

This problem is not only of importance from the standpoint of

the physiology of seed production, but of considerable interest from the fact that in *Staphylea* there is a selective mortality with respect to number of ovules, ovaries with a smaller number of ovules being less capable of developing into mature fruits than those with a larger number.*

The determination of the existence of such a relationship, especially the measurement of its intensity, presents considerable difficulty. It is desirable that degree of interdependence shall be expressed in terms of correlation, but there are dangers of spurious coefficients. Again, the work so far done has demonstrated very low correlations between somatic characters, or those of the fruit, and seed production. One would, therefore, anticipate very slight relationships between the number of ovules formed per fruit and its capacity for seed development. In such cases very large and numerous series of data are desirable.

II. METHOD OF ANALYSIS

I believe the following method of reasoning is valid.

In a series (a population, to use the technical term) of polyspermous fruits only a portion of the ovules develop into mature seeds. Let o be the number of ovules formed and s the number of seeds matured per fruit; both are variable; s is always some proportion of o. If there be no relationship between the absolute number of ovules formed and the capacity of the fruit for maturing its seeds, the most probable number of seeds for any pod is po, where

$$p = \bar{s}/\bar{o},$$

the bars indicating the mean value of the two variables. Now let $z = s - po$, or the deviation of any individual s from its probable value, on the assumption that the chances of an individual ovule developing into a seed are independent of the number of ovules in the ovary in which it is produced. The correlation coefficient between o and z, r_{oz}, should furnish the information we need.

A convenient formula for the determination of this relation-

* Harris, J. Arthur, Biometrika 7: 452–504. 1910; Science II. 32: 519–528. 1910; Pop. Sci. Mo. 78: 521–538. 1911.

ship was most kindly worked for me while engaged on this problem at University College, London, by Professor Karl Pearson.*

III. DISCUSSION OF DATA

This formula has been so far applied to the problem of fecundity in plants only in the case of the fruits of *Cercis*, *Robinia* and *Sanguinaria* and of the inflorescence of *Staphylea*, *Celastrus* and *Crinum*.† Only one or two published series were available for each of these species. Because of the delicate relationships which are ordinarily found between fertility and other characters‡ it is essential for trustworthy results that the relationship be worked out on as large a series of material as possible. It will be also advantageous if one can include a large number of sub-series differing from each other in the conditions to which they have been subjected but each homogeneous in itself.

The only such series of data is that used for the working out of the relationship between bilateral asymmetry and fertility and fecundity in *Phaseolus vulgaris*.§ For each of these 53 series, embodying altogether over 170,000 pods, I have carried through the arithmetical routine necessary for the determination of r_{oz}, the correlation between the number of ovules formed per pod and the deviation of the number of seeds from their probable value on the assumption of there being no relationship between the number of ovules formed and the capacity of the pod for maturing its seeds.

TABLE I gives the results. The key letters indicating the individual series permit easy reference to other published information concerning them. The second column shows the number of pods upon which the determinations are based. The third gives the coefficient of correlation between the number of ovules and

* Harris, J. Arthur, The Correlation between a Variable and the Deviation of a Dependent Variable from its Probable Value. Biometrika **6**: 438–443. 1909.

† For the results for the fruits of *Cercis*, and *Robinia* and the inflorescence of *Staphylea* see the original paper on methods. For *Sanguinaria* see Biometrika **7**: 321–324. 1910. For *Celastrus* see Missouri Bot. Gard. Ann. Rep. **20**: 116–122. 1909, and for *Crinum* see Missouri Bot. Gard. Ann. Rep. **23**: 85–89. 1912.

‡ For a review of the pertinent literature for plants see Biometrika **8**: 52–65. 1911.

§ Harris, J. Arthur, in Roux's Archiv. f. Entwicklungsmech. Organism. **35**: 500–522. 1912.

TABLE I

Series	N	r_{os}	r_{oz} and Probable Error	r_{oz}/Er_{oz}
L	1804	.374	−.040 ± .016	− 2.52
LL	8043	.357	−.014 ± .008	− 1.80
LG	806	.107	−.189 ± .023	− 8.27
BW1	346	.177	−.234 ± .034	− 6.82
BW2	467	.128	−.290 ± .029	−10.15
G	696	.542	−.012 ± .026	− .47
GG	6310	.247	−.102 ± .006	−17.25
GGH	5251	.461	−.101 ± .009	−10.98
GGH2	3502	.517	−.045 ± .011	− 3.94
GGHH	2656	.489	−.068 ± .013	− 5.20
GGD	1438	.362	−.069 ± .018	− 3.88
GGD2	1227	.426	−.020 ± .019	− 1.04
GGDD	807	.386	−.022 ± .024	− .95
H	5141	.444	+.012 ± .009	+ 1.23
HH	14029	.511	−.015 ± .006	− 2.68
HHC	2355	.504	+.121 ± .014	+ 8.82
HHH	11230	.426	−.057 ± .006	− 9.02
HHHC	2614	.501	+.101 ± .013	+ 7.69
HD	5581	.418	−.040 ± .009	− 4.47
HDC	1733	.509	+.086 ± .016	+ 5.32
HDD	5449	.500	+.026 ± .009	+ 2.87
HDDC	2308	.464	+.097 ± .014	+ 6.97
D	1473	.521	+.055 ± .018	+ 3.17
DD	1827	.496	−.046 ± .016	− 2.91
DDC	1159	.463	+.066 ± .020	+ 3.35
DDD	2018	.444	−.018 ± .015	− 1.17
DDDC	1542	.429	+.047 ± .017	+ 2.77
DH	5955	.548	+.029 ± .009	+ 3.29
DHC	2077	.409	+.045 ± .015	+ 3.05
DHH	5019	.446	−.052 ± .010	− 5.48
DHHC	2494	.438	+.055 ± .014	+ 4.06
USC	2569	.331	−.064 ± .013	− 4.79
USS	6605	.505	+.071 ± .026	+ 2.78
USSC	1888	.332	−.065 ± .016	− 4.21
USH	3406	.470	−.041 ± .012	− 3.60
USHC	1570	.322	−.091 ± .017	− 5.38
USHH	1743	.366	−.035 ± .016	− 2.18
USHHC	1936	.318	−.106 ± .015	− 6.95
USD	802	.376	−.018 ± .024	− .74
USDC	1810	.245	−.154 ± .016	− 9.91
USDD	851	.370	−.027 ± .023	− 1.17
USDDC	1619	.315	−.116 ± .017	− 7.05
FSC	2876	.344	−.056 ± .013	− 4.50
FSS	7809	.367	−.049 ± .008	− 6.42
FSSC	2457	.411	+.035 ± .014	+ 2.57
FSH	4541	.458	−.004 ± .010	− .38
FSHC	2117	.268	−.155 ± .014	−10.84
FSHH	3837	.398	−.028 ± .011	− 2.59
FSHHC	3180	.325	−.089 ± .012	− 7.43
FSD	1449	.433	+.002 ± .018	+ .12
FSDC	1506	.267	−.134 ± .017	− 7.83
FSDD	1556	.421	−.016 ± .017	− .92
FSDDC	2646	.328	−.101 ± .013	− 7.73

number of seeds per pod, r_{os}, while the fourth contains the correlations between the number of ovules per pod and the deviation of the number of seeds from their probable value.

All of the values for r_{os} are positive, and of a substantial order of magnitude. Both positive and negative coefficients for r_{os} occur, and the values are low throughout. Of the 53 determinations, 38 are negative and 15 positive in sign. Were there no biological relationship between *o* and *s* an equal number of positive and negative values would be expected. Thus there is a deviation from equality of 11.5 ± 2.46,* which is probably significant.

Thus there is apparently a distinct negative relationship between *o* and *z*. This conclusion is supported by restricting the constants upon which it is based to those which are more probably statistically significant with regard to their probable errors. Thus I find that for the 41 constants 2.5 and more times their probable error 28 are negative and 13 are positive. Of the 26 constants which are over 4 times their probable error, 21 are negative and 5 are positive. Of the 13 which are over 7 times their probable error, 11 are negative and 2 are positive.

Taking means of the ratio of the correlation coefficients to their probable errors, I find a mean ratio of 5.10 for the negative values and of 3.87 for the positive. Thus the negative constants are as a whole more trustworthy than are the positive, although some of the positive values must be certainly regarded as trustworthy statistically.

Consider next the relative magnitude of the positive and negative coefficients. The 38 negative constants give a mean value of $-.0732$ while the 15 positive correlations give a mean value of $+.0529$. Thus the negative coefficients are numerically larger than the positive.

I now split the materials up into the individual varieties. The results are conveniently summarized in TABLE II.

Positive coefficients occur only in Navy, Ne Plus Ultra and White Flageolet. In the two latter, only 3 of the 22 constants are positive, and neither of the three can be safely regarded as significant with regard to its probable error. In Navy, quite different conditions seem to prevail. In both strains 6 of the 9

* Calculated from $.6745\sqrt{53 \times .5 \times .5}$.

constants are positive. Numerically, the positive constants average higher than the negative, and in comparison with their probable errors they seem to be more trustworthy, the values of the ratio of r_{oz} to its probable error averaging higher in the positive than

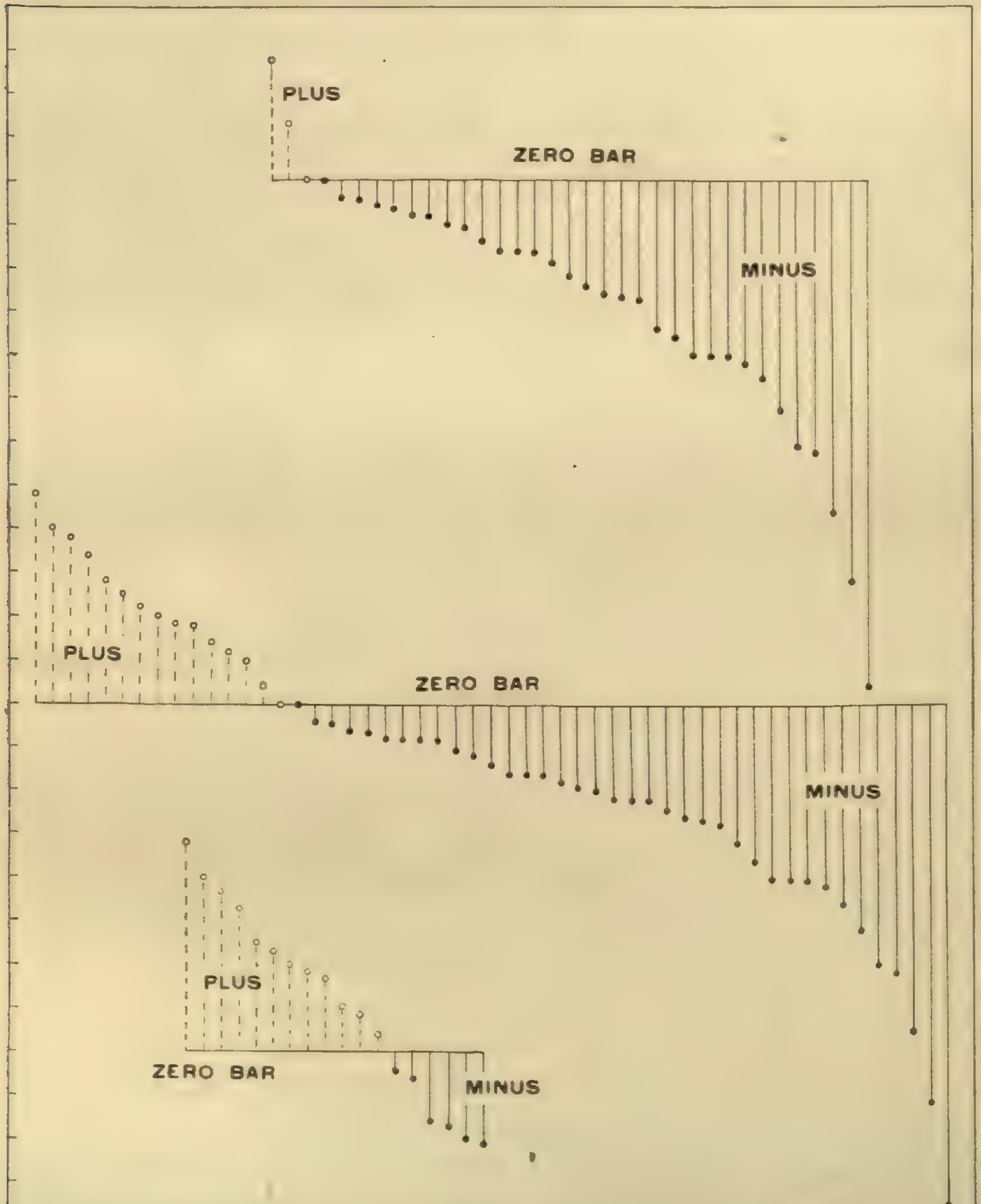

DIAGRAM 1. Intensities of correlation. One interval on marginal scale = .052.

in the negative cases. Just the reverse of this condition is found everywhere else. All of the positive values which are over thrice their probable error fall in the Navy strains.

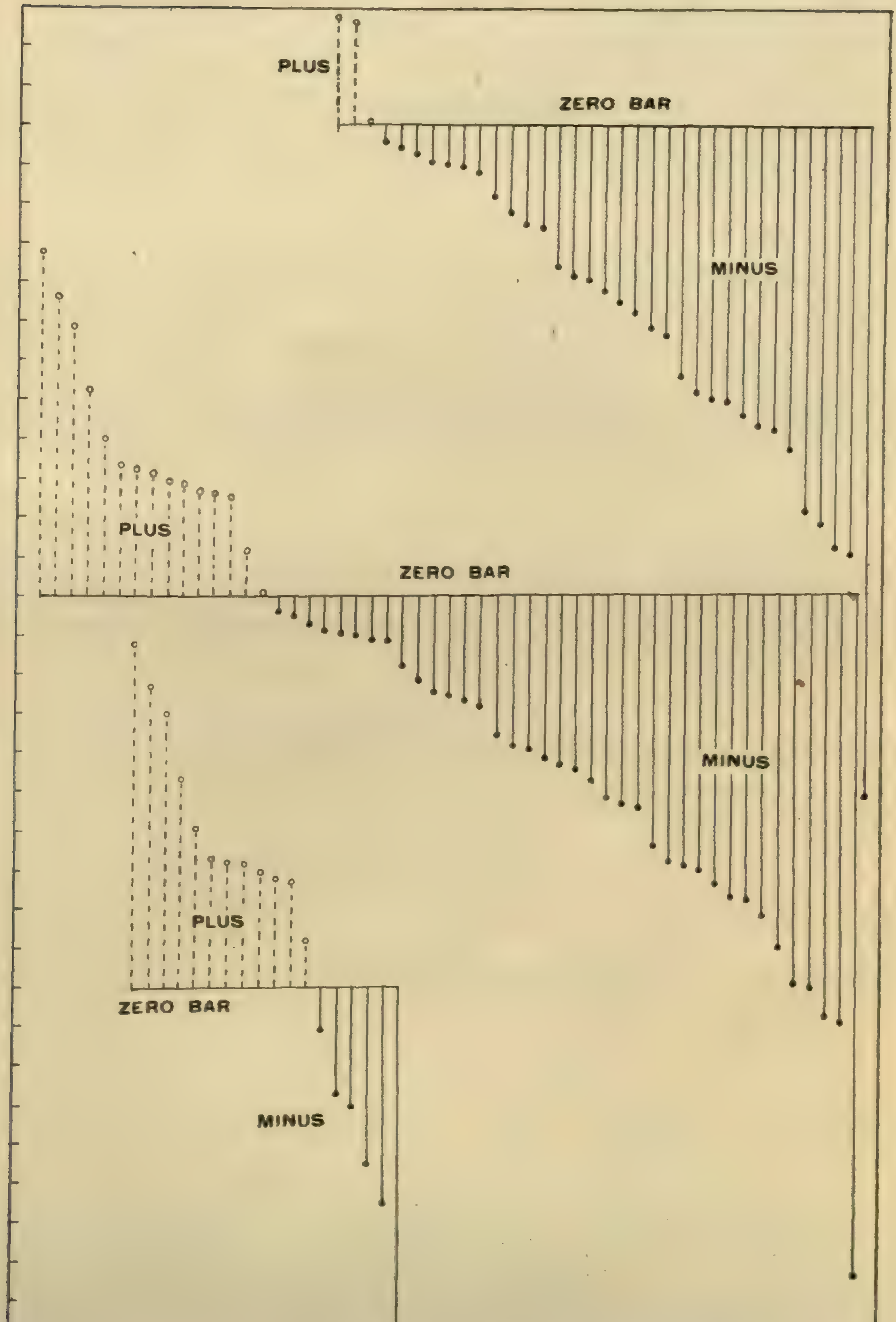

DIAGRAM 2. Significance of correlations as indicated by the ratio to their probable error. One interval on marginal scale = 1.

These relationships are forcibly shown in DIAGRAMS I and II. In both of these the intensity of the correlation is shown by the

TABLE II

Variety	Number of cases	Mean r_{oz}	Mean $r_{oz}/E_{r_{oz}}$
Golden Wax			
Plus	—	—	—
Minus	3	−.081	−4.20
Black Wax			
Plus	—	—	—
Minus	2	−.262	−8.49
Burpee's Stringless			
Plus	—	—	—
Minus	8	−.055	−5.46
Navy H			
Plus	6	+.074	+5.48
Minus	3	−.037	−2.70
Navy D			
Plus	6	+.050	+3.28
Minus	3	−.039	−3.19
Ne Plus Ultra			
Plus	1	+.017	+2.78
Minus	10	−.072	−4.60
White Flageolet			
Plus	2	+.014	+1.35
Minus	9	−.070	−5.40

length of the vertical lines. The broken ones extending above the zero bar measure positive values; the solid ones extending below the zero bar indicate negative coefficients. In DIAGRAM I the lengths of the lines are in terms of the correlation coefficients, r_{oz}; in DIAGRAM 2 they are in terms of the ratio of the correlation to its probable error. In both, the large central figure represents the distribution of values for the whole material. This is analyzed into the Navy series, shown in the lower corner, and into all other series, shown in the upper right hand corner of the figures. The difference in the contribution of these two elements to the general series is very striking.

IV. RECAPITULATION AND DISCUSSION

In dwarf varieties of garden beans, *Phaseolus vulgaris*, there is but a slight relationship between the number of ovules per ovary and its capacity for maturing these ovules into seeds. So lax is this correlation that in working with only moderately large samples both positive and negative values of the coefficient may be found in the same strain of material.

Such a relationship does, however, exist. So far as the materials available may be considered as representative of the species it is generally negative, i. e., as the number of ovules formed increases the capacity for maturing these ovules into seeds decreases. This conclusion is supported by the facts that the negative correlations are significantly more numerous than the positive, they average larger numerically, and they have a higher degree of trustworthiness with regard to their probable errors.

In some varieties, however, the correlations seem to be generally positive. This is true for the common Navy. All other varieties so far as studied—White Flageolet, Ne Plus Ultra, Burpee's Stringless, Golden Wax and Black Wax—show exclusively or preponderantly negative correlations.

Concerning the explanation of this relationship no suggestion can be made. Such an attempt would be quite premature until ample quantitative data on the nature (sign) and intensity of the relationship in a considerable series of varieties are available. Anyone venturing to suggest explanations must also fully realize that the problem is an exceedingly complex one, involving many difficulties which need not be enlarged upon here. But as matters of biological fact the results seem definitely established, and represent one further step in the analysis of the problem of fertility and fecundity in plants.

COLD SPRING HARBOR, N. Y.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

Vol. 40 No. 9

BULLETIN

OF THE

TORREY BOTANICAL CLUB

SEPTEMBER, 1913

Studies on the Rocky Mountain flora — XXIX

PER AXEL RYDBERG

MONOTROPACEAE

Hypopitys latisquama Rydb. sp. nov.

Plant pink, 1–3 dm. high, more or less short-pubescent above; scales of the stem broadly ovate, obtuse, 1–1.5 cm. long; flowers usually 10–15; sepals spatulate or cuneate, 8–10 mm. long, abruptly acuminate, ciliate; petals cunate or obovate, 11–12 mm. long, rounded and sinuate at the apex, pubescent and ciliate, filaments and style copiously hairy; stigma retrorsely bearded.

This is closely related to *H. lanulosa* (Michx.) Nutt., but differs in the large and broad scales on the stem and the larger flowers.

MONTANA: Bridger Mountains, July 28, 1896. *Flodman 708* (type, in herb. N. Y. Bot. Gard.).

WYOMING: 1873, *Parry 196*.

WASHINGTON: Olympic Mountains, *Elmer 2464*.

PRIMULACEAE

Primula specuicola Rydb. sp. nov.

Perennial with a short rootstock; leaves 5–13 cm. long, thin, slightly farinose when young, in age glabrate, with winged petioles; blades spatulate or elliptic, obtuse at the apex, sinuate-dentate; scape 1–1.5 cm. long; umbels 10–20-flowered; bracts linear-subulate, thin, 5–10 mm. long, slightly gibbous at the base; pedicels 5–10 mm. long in flower or 1–4 cm. long in fruit; calyx densely farinose; tube deeply campanulate, 3–5 mm. long; lobes linear-oblong, 2.5–3.5 mm. long, obtusish; corolla-tube yellowish, 8–10

[The BULLETIN for August (**40**: 377–460. *pl. 21, 22*) was issued 13 Au 1913.]

mm. long, 1.5 mm. in diameter; lobes cuneate, merely emarginate with a broad sinus, dark violet, about 3 mm. long; stamens inserted in the middle of the corolla-tube; capsule about 6 mm. long.

This species is related to *P. farinosa* L. and *P. incana* M. E. Jones, but differs from both in its very thin leaves, more exserted corolla-tube and slender bracts. In *P. incana* M. E. Jones (*P. americana* Rydb.), the only other species of the group in the Rocky Mountains, the bracts are thick, almost fleshy, obtusish, lanceolate, and often nearly equaling the pedicels. In the bracts and inflorescence, it resembles more *P. farinosa* L. of Europe and northeastern America. *P. Ellisiae* of the Sandea Mountains of New Mexico, though belonging to this group and of the same habit, has much larger flowers, the lobes of the corolla being 8–10 mm. long. *P. specuicola* grows only in loose soil, under overhanging cliffs in the alcove-like heads of the canyons, characteristic of the limestone bluffs of San Juan River.

UTAH: Along San Juan River, near Bluffs, Aug. 25–29, 1911, *Rydberg 9882* (type, in herb. N. Y. Bot. Gard.); same locality, Feb., 1912, *Edna Scorup*, and in 1895, *Alice Eastwood.*

Androsace albertina Rydb. sp. nov.

Cespitose perennial, but scarcely pulvinate; leaves narrowly oblanceolate, about 1 cm. long, sparingly ciliate, not carinate; scape 5–10 cm. long, slender, sparingly hairy; bracts linear-lanceolate, 3–4 mm. long; pedicels 3–5 mm.; calyx-lobes elliptic, obtuse; corolla-lobes 2–3 mm. long.

This is most like the European *A. Chamaejasme* Host, but the leaves and bracts are narrower. It differs from *A. carinata* Torr. in the narrower leaves, not carinate beneath, less pulvinate habit, longer peduncles, longer pedicels, and smaller flowers.

ALBERTA: Lake Agnes, National Park, Banff, Aug. 1897, *Mr. and Mrs. C. Van Brunt 77* (type, in herb. N. Y. Bot. Gard.); Jumping Pound Creek, June 14, 1897, *Macoun 23478;* Rocky Mountains 1858, *Bourgeau.*

MONTANA: Yellow Mountain, June 24, 1897, *R. S. Williams.*

Androsace simplex Rydb. sp. nov.

Annual; leaves oblanceolate, 3–6 mm. long, acute, entire, minutely puberulent; scape usually solitary, erect, very slender, 2–7 cm. high; bracts oval or lance-oval, 2–4 mm. long; pedicels

5–15 mm. long, suberect or strongly ascending; calyx-tube obpyramidal, about 2 mm. long; lobes lanceolate, about 1.5 mm. long, acute; corolla small, shorter than the calyx.

This is related to *A. occidentalis*, but the plant is more delicate, the scapes solitary, bearing a 1–4-flowered umbel with strongly ascending or nearly erect pedicels, the bracts smaller and distinctly acute.

MONTANA: Missoula, May, 1897, *Elrod & assistants 33* (type, in herb. N. Y. Bot. Gard.).

UTAH: Near Salt Lake City, May 1882, *M. E. Jones.*

BRITISH COLUMBIA: Lytton, April 17, 1889, *Macoun.*

Dr. Greene separates an American species *Androsace capillaris* Greene from the Asiatic *A. filiformis* Retz, and claims that the former is a perennial. All American specimens that I have seen are, however, annuals, and I can see no reason for such a separation.

Dodecatheon Jaffreyi Moore has been collected near Sawtooth, Idaho, by Evermann.

GENTIANACEAE

Anthopogon ventricosum (Griseb.) Rydb.

Gentiana ventricosa Griseb. in Hook. Fl. Bor.-Am. 2: 65. 1838.

Anthopogon Macounii (Holm) Rydb.

Gentiana Macounii Holm, Ottawa Nat. **15**: 110, 179. 1901.

Anthopogon tonsum (Lunell) Rydb. sp. nov.

Gentiana detonsa tonsa Lunell, Bull. Leeds Herb. **2**: 7. 1908.

This is closely related to *A. Macounii* (Holm) Rydb., but differs in the glabrous filaments, a character not pointed out by Dr. Lunell.

Amarella tortuosa (M. E. Jones) Rydb.

Gentiana tortuosa M. E. Jones, Proc. Calif. Acad. II. **5**: 707. 1895.

Amarella ventorum Rydb. sp. nov.

Gentiana arctophila densiflora Torr. Fremont's Rep. 94. 1845.

Not *G. arctophila densiflora* Griseb.

Low annual or biennial, branched near the base; stems 5–10 cm. long, branched, internodes shorter than the leaves; basal

leaves oblanceolate; stem-leaves linear or linear-lanceolate, about 2 cm., acute; flowers 1–3 in the axils; pedicels 2–8 mm. long; calyx-tube about 2 mm. long; lobes linear-lanceolate, 3–5 mm. long, acute, scabrous on the margins; corolla about 5 mm. long; lobes ovate, obtuse or acute; crown none.

This little *Amarella* lacks the setaceous fimbriate crown at the base of the corolla-lobes and therefore should be classified with the arctic or subarctic *A. propinqua* (Richards.) Greene, and *A. arctophila* (Griseb.) Greene, but the corolla-lobes are acute or obtuse, instead of cuspidate.

WYOMING: Wind River Moutainns, Aug. 4, 1843, *Fremont.*

Dasystephana oregana (Engelm.) Rydb.

Gentiana oregana Engelm.; A. Gray, Syn. Fl. **2**[1]: 122. 1878.

Dasystephana glauca (Pall.) Rydb.

Gentiana glauca Pall. Fl. Ross. **2**: 104. 1784.

Dasystephana calycosa (Griseb.) Rydb.

Gentiana calycosa Griseb. Gen. et Sp. Gent. 292. 1839.

Dasystephana monticola Rydb. sp. nov.

Gentiana calycosa stricta Griseb. Gen. et Sp. Gent. 292. 1839.
Gentiana calycosa monticola Rydb. Bull. Torrey Club **24**: 252. 1897.

Dasystephana obtusiloba Rydb. sp. nov.

Cespitose perennial; stems erect or ascending, about 1 dm. high; internodes short, equaling or a little longer than the leaves; leaves very broadly ovate, 3–5-ribbed, usually acute at the apex and subcordate at the base; calyx-tube broadly turbinate, 5–6 mm. long; lobes broadly oval, rounded at the apex, often overlapping, about 8 mm. long; corolla dark blue, about 3.5 cm. long; lobes rounded at the apex; lobes of the plaits about half as long as the corolla lobes.

This is related to *D. calycosa*, but differs in the lower habit and rounded corolla-lobes.

MONTANA: Mary Baker Lake and Sperry Glacier, Aug. 21, 1901, *Vreeland 1162* (type, in herb. N. Y. Bot. Gard.); Lake MacDonald, Aug. 22, 1901, *Umbach 371;* Mount MacDonald, July 25, 1900, *Elrod & assistants;* Silloway Peak, July 17–19, 1901, *MacDougal 692;* Blackfoot Indian Reservation, Aug. and Sept. 1909, *Gilman Thompson.*

Swertia Fritillaria Rydb.

Glabrous, light green, perennial; stem 1.5–3 dm. high; basal leaves and lower stem-leaves alternate, 6–10 cm. long, thin, long-petioled; blades obovate, spatulate, rounded at the apex, abruptly contracted into winged petioles of about the same length; middle and upper stem-leaves all alternate or a single pair of opposite ones, oblanceolate or oblong; inflorescence rather lax, elongate; pedicels 1–2 cm. long; sepals lanceolate, about 6 mm. long; corolla-lobes lanceolate, mostly acute, greenish white along the midrib and azure along the margins, dotted all over with dark blue spots in the manner of many species of *Fritillaria;* filaments more or less dilated, some of them very broad; glands inconspicuous with rather long blue fringes.

UTAH: Wet places in caynons: Big Cottonwood Canyon, August 4, 1905, *Garrett 1566* (type, in herb. N. Y. Bot. Gard.).

APOCYNACEAE

Amsonia Eastwoodiana Rydb. sp. nov.

Perennial, with a short woody base; stem 3–5 dm. high, glabrous; stem-leaves lanceolate, usually narrowly so, 3–5 cm. long, glabrous, acute at each end; leaves of the numerous strongly ascending branches linear; calyx-lobes subulate, 2 mm. long or longer; corolla 16–20 mm. long; tube narrowly trumpet-shaped; lobes nearly 4 mm. long; pod 5–8 cm. long, about 8 mm. thick, constricted and often breaking off between the seeds, 3–5-seeded; seeds oblong, about 1 cm. long and 6 mm. thick.

This is most closely related to *A. brevifolia*, having the same flower and fruit, but the plant is in habit more like *A. Fremontii*, for which it has been mistaken. The latter has still longer calyx-lobes which are narrower, and its pod is not restricted between the seeds. In canyons of desert regions.

UTAH: Moab, July, 1911, *Rydberg & Garrett 8468* (fruit, type, in herb. N. Y. Bot. Gard.); Willow Creek Canyon, August, 1895, *Alice Eastwood 73* (fruit).

ARIZONA: Ten miles east of Holbrook, June 22, 1901, *L. F. Ward* (flowers); Lee's Ferry, 1890, *M. E. Jones*.

Amsonia texana (A. Gray) Heller of the Flora of Colorado and Coulter & Nelson's Manual is *A. latifolia* Jones. *A. brevifolia* A. Gray, and *A. tomentosa* Torr. have been collected in southern Utah.

ASCLEPIADACEAE

Astephanus utahensis Engelm., *Philibertella cynanchoides* (Dec.) Vail and *P. heterophylla* (Engelm.) Vail, *Asclepias erosa* Torr., *A. macrosperma* Eastw. and *A. labriformis* Jones have been collected in Utah; *Acerates lanuginosa* (Nutt.) DC., in the Yellowstone Park; *Asclepias ovatifolia*, in Saskatchewan; and *Asclepias mexicana* Cav., in Idaho.

CONVOLVULACEAE

Cressa erecta Rydb. sp. nov.

Stem branched, with a woody base, erect, 2–3 dm. high with erect branches, silvery canescent; leaves elliptic, 5–7 mm. long, acute at both ends, sessile, silvery canescent; pedicels in fruit 6–10 mm. long, usually exceeding the leaves; bracts elliptic, 3 mm. long; sepals 4–5 mm. long, oval, equaling the corolla-tube; corolla white; lobes elliptic, acutish, rarely spreading; filaments filiform, slightly pubescent; ovary densely pubescent; styles filiform.

This differs from *C. depressa* Goodding in the erect stem and branches, the more silvery pubescence, the longer pedicels (in *C. depressa* shorter than the leaves) and the comparatively narrower corolla-lobes.

UTAH: Near Beck's Hot Springs, Salt Lake County, July, 1905, *Garrett 870f* (type, in herb. N. Y. Bot. Gard.).

CUSCUTACEAE

Cuscuta curta (Engelm.) Rydb. sp. nov.

Cuscuta Gronovii curta Engelm. Trans. St. Louis Acad. 1: 507. 1859.

In saline districts of Utah and Colorado.

POLEMONIACEAE

Dr. Brand* reduces the amply distinct *Phlox muscoides* Nutt. to

* Pflanzenreich, Vol. 4, Fam. 250. The following pages contain a good deal of criticism of Dr. Brand's monograph of this family. The monograph is one of the best, differing in that respect from most works done by Europeans on American plants. The citation of publication is very carefully prepared, correct, and complete; but Dr. Brand has fallen into the same errors as most foreigners do, in not trying to find out exactly what the types are or what plants the descriptions really represent. He made definite pronunciations as to species he had never seen, and made synonyms from mere guesses. My criticisms are limited to the Rocky Mountain species. If the Pacific Slope species are considered, probably as many more incongruities could be pointed out.

a subspecies of *P. caespitosa* and makes *P. Covillei* E. Nels. and *P. condensata* (Gray) E. Nels. varieties of this subspecies. It is evident that Dr. Brand does not know what *P. muscoides* is; for the only Montana specimen he cites is *Rydberg & Bessey 4815*, which belongs to *Phlox caespitosa* and is so referred in my Flora of Montana. He also cites two specimens from California, *Coville 2072* from Mount Whitney and *Hildebrand* from Silver Mountains and also one from Charleston Mountains, Nevada, *Purpus 6111*. *Phlox muscoides* Nutt. is unknown to both California and Nevada. Neither *P. Covillei* nor *P. condensata* is closely related to *P. muscoides*. The relationship of *P. muscoides* is with *P. bryoides* on one hand, and *P. Hoodii* on the other; and the calyx is arachnoid-villous, not glandular as in *P. caespitosa*.

Dr. Brand made *Phlox albomarginata* M. E. Jones, *P. costata* Rydb., *P. collina* Rydb. and *P. diapensioides* Rydb. varieties of *P. Kelseyi*, while he kept *P. alyssifolia* Greene as distinct and described a new species, *P. variabilis*, from material which I had included in *P. collina*. It is evident that Dr. Brand did not know the plants he was so treating. Under his var. *albomarginata* he gives the following distribution:

"Montana (nach Jones)—Wyoming: Cooper Creek (Nelson n. 4336)."

Evidently he had not seen Jones's specimens and *Nelson 4336* is typical *P. Kelseyi*, and has nothing of the habit of *P. albomarginata*.

Under each of his var. *collina* and var. *diapensioides* he gives the following: "Montana (nach Rydberg)." In other words, he had seen no specimens. Under his var. *costata* he gives: "Montana: Madison Co. (Nelson 5148)." This number is not found in the herbarium of the New York Botanical Garden, but judging from the rest I am inclined to think that this determination is just as unreliable. It may be that *5148* is a misprint for *5418*, which is labeled *Phlox Kelseyi*, and should be referred to it, but is not typical. It has nothing to do with *P. costata*. Furthermore, *P. costata* is not closely related to *P. Kelseyi*, but intermediate between *P. multiflora* A. Nels. and *P. glabrata* (A. Nels.) Brand, but with a densely pubescent calyx.

In my opinion, *P. alyssoides* Greene, *P. collina* Rydb., and *P.*

variabilis Brand are one and the same species. I included *Hall & Harbour 454* in the original description of *P. collina*, and I have no reason for changing my opinion. There is no essential difference between my diagnosis of *P. collina* and Brand's characterization of *P. variabilis*, except that I described the leaves as "oblong or ovate" and Brand gives them as "linear." The specimens in the Columbia University herbarium of *Hall & Harbour 454* have oblong leaves, hence agreeing better with my description. Furthermore, *P. alyssoides* (= *P. collina*), as I understand it, has been collected at several places in both Utah and Wyoming, and why not also in Colorado? Professor A. Nelson in Coulter & Nelson's New Manual has followed Dr. Brand's treatment of this group very closely. It would have been much better for him to find out the real facts.

Brand's description of *P. Douglasii* is not correct; he describes the calyx as eglandulose-pilose, while the duplicate of the type in the Columbia University herbarium is densely glandular.

Phlox dasyphylla Brand is not better than *P. variabilis*, being only a small-flowered and narrow-leaved form of *P. multiflora*, not uncommon in Colorado and Wyoming.

Phlox densa Brand is a low condensed from of *P. austromontana*, more like the type than *Phlox austromontana prostrata* E. Nels., which Dr. Brand regards as a mere variety. The only one of Dr. Brand's new species from the Rockies that I regard as good is *P. glabrata* (E. Nels.) Brand (*P. Hoodii glabrata* E. Nels.).

In describing *Phlox aculeata** Prof. A. Nelson compares it with the *P. caespitosa* group. The intercostal portion of the calyx is replicate, however, which would associate it with *P. Stansburyi*. I can not distinguish it from *P. viridis* E. Nels.

Dr. Brand's conception of *Gilia congesta* Hooker is entirely wrong. He regards *G. iberidifolia* Benth. as the typical *G. congesta*. A duplicate of Douglas's plant is found in the Columbia University herbarium, and a closer study of the same shows that it is the same as Jenney's plant from the Black Hills, which constituted a part of *G. spicata capitata* A. Gray, and my number *886*, also from the Black Hills. These two specimens I included in my *G. cephaloidea*. Unfortunately I did not designate a type and some botanists might claim that Jenney's plant which was first

* Bot. Gaz. 52: 270. 1911.

mentioned should be regarded as such. The short characterization was, however, drawn principally from my number *2763* from Lima, Montana, and this is marked in our herbarium as the type. Since more specimens have been seen, both of the Montana plant and of that from the Black Hills, it has become evident that they are not exactly the same. As the Montana plant is marked as the type, I now limit my *G. cephaloidea* to it. If Jenney's plant or my *886* were to be regarded as the type of *G. cephaloidea*, this would become a synonym of *G. congesta* and the Montana plant should have a new name. As it is, the *G. cephaloidea* of Brand's monograph should become *G. congesta* Hooker, and Brand's *G. congesta* is *G. iberidifolia* Benth.

Brand divides the *Gilia spicata* group in two divisions: one containing *G. spicata*, *G. globularis* and *G. trifida*, with the corolla-lobes (in dry state) dark purple; and *G. cephaloidea* and *G. congesta*, with lobes of the corolla (in dry state) whitish. The dark purple color is simply due to poor drying. Dr. Brand also describes the corollas of *G. spicata* as purple. In fact they are greenish white. We have specimens of *G. spicata* which still retain the greenish white color. Such a distinction is scarcely scientific.

Under *Gilia congesta iberidifolia*, Dr. Brand gives as synonyms *G. spergulifolia* Rydb. and *G. roseata* Rydb. Evidently Dr. Brand had not seen a specimen of *G. roseata*. This is perhaps closer related to his own *G. globularis* than to *G. iberidifolia*, except that the stems are branched and bear several heads. He had seen a specimen of *Baker 534*, which I referred to *G. spergulifolia*. When doing so I had in mind only the specimen in the herbarium of the New York Botanical Garden. I do not know by what this number may be represented elsewhere. However, I can not distinguish this from *Nelson 5430*, which Dr. Brand refers to the var. *crebrifolia*, evidently not knowing that the var. *Merrillii* (*G. Merrillii* A. Nels.) is the original *G. crebrifolia* Nutt. A duplicate of the type is in the Columbia University herbarium. The synonomy of this group of Gilias is therefore very mixed. In order to straighten out the matter I give the following synonymy:

GILIA SPICATA Nutt. Jour. Acad. Nat. Sci. Phila. II. 1: 156. 1848.

GILIA GLOBULARIS Brand, Pflanzenreich 4^{250}: 120. 1907.

Gilia spicata capitata A. Gray, Proc. Am. Acad. 8: 274 (as to type). 1870.

Gilia cephaloidea Rydb. Fl. Colo. 277, in part. 1906.

GILIA CEPHALOIDEA Rydb. Bull. Torrey Club 24: 293 (as to the Montana plant). 1897.

GILIA CONGESTA Hook. Fl. Bor.-Am. 2: 75. 1838.

Gilia spicata capitata A. Gray, Syn. Fl. 2^1: 144, in part. 1878.

Gilia cephaloidea Rydb. Bull. Torrey Club 24: 293, in part. 1897.—Brand, Pflanzenreich 4^{250}: 121. 1907.

GILIA IBERIDIFOLIA Benth. in Hook. Jour. Bot. & Kew Misc. 3: 290. 1851.

Gilia congesta iberidifolia Brand, Pflanzenreich 4^{250}: 121. 1907.

Gilia nuda (Eastw.) Rydb.

Gilia congesta nuda Eastw. Proc. Calif. Acad. II. 6: 308. 1896.

GILIA ROSEATA Rydb. Bull. Torrey Club 31: 633. 1904.

GILIA SPERGULIFOLIA Rydb. Bull. Torrey Club. 31: 633. 1904.

Gilia congesta crebrifolia S. Wats. Bot. King Exped. 5: 268, in part. 1871.

Gilia congesta iberidifolia crebrifolia Brand, Pflanzenreich 4^{250}: 121. 1907.

GILIA CREBRIFOLIA Nutt. Jour. Acad. Nat. Sci. Phila. II. 1: 156. 1848.

Gilia congesta crebrifolia A. Gray, Proc. Am. Acad. 8: 273. 1870.

Gilia Merrillii A. Nels. Bot. Gaz. 34: 27. 1902.

Gilia congesta iberidifolia Merrillii Brand, Pflanzenreich 4^{250}: 122. 1907.

GILIA BURLEYANA A. Nels. Bot. Gaz. 54: 144. 1912.

This species also belongs to this group. Prof. Nelson stated in the original description: "Until now this section contained no perennials." Both *G. iberidifolia* and *G. roseata* are perennials. Gray divides the group in "annuals and short lived perennials or biennials."

Gilia palmifrons (Brand) Rydb. sp. nov.

Gilia congesta palmifrons Brand, Pflanzenreich 4^{250}: 122. 1907.

I think also that Dr. Brand has misidentified *Gilia trifida* Nutt.

Dr. Brand evidently drew his description from *Jones 5949*, the only specimen he cited. He described the stamens as being inserted in the middle of the corolla-tube, while Nuttall described them as inserted in the throat. I have not seen Nuttall's type, but I have collected in the region of the type locality, Scott's Bluffs, Nebraska. The only species growing there are *G. spicata* and *G. iberidifolia*. I believe that Dr. Gray interpreted *G. trifida* Nutt. correctly as a depauperate form of *G. spicata*. If this is correct, Brand's *G. trifida* must receive a new name.

Gilia frutescens Rydb. sp. nov.

Fruticose, perennial; stems woody below, branched above, 3–5 dm. high; herbaceous branches 2–3 dm., sparingly pubescent; leaves linear, glabrous or nearly so, simple, 2–5 cm. long, 1–2 mm. wide, callous-tipped; flowers capitate at the ends of the branches; calyx crisp-hairy; teeth lanceolate, cuspidate, shorter than the tube; corolla white, 5–6 mm. long, salvershaped; tube barely exserted; lobes about 2.5 mm. long, oval, acute; stamens inserted in the throat; filaments short; style glabrous, nearly as long as the corolla tube.

The type was labeled *Gilia multiflora*, to which it is not related. It belongs to the *G. iberidifolia* group, and has as entire leaves as *G. spergulifolia* and *G. crebrifolia*, but the habit is different. It differs from all its relatives in the tall shrubby habit. The other species are at most suffruticose and less than 3 dm. high.

UTAH: Springdale, May 14, 1894, *M. E. Jones 5247* (type, in herb. N. Y. Bot. Gard.; duplicate in U. S. Nat. Herb. *no. 326910*).

Dr. Brand has treated the *G. aggregata* group as carelessly as that of the *G. congesta* relatives. It is evident that he has had no specimens of *G. candida* Rydb. and still he makes it *Gilia aggregata* var. *attenuata* forma *candida*, giving *Callisteris leucantha* Greene as another synonym. If he had only read my description, he would not have committed this blunder, for I distinctly pointed out that the lobes of the corolla in *G. candida* are rounded or obtuse at the apex like those of *G. longiflora*. It is a plant with the habit and leaves of *G. aggregata* and the corolla of *G. longiflora*. Both *Callisteris attenuata* and *C. leucantha* have attenuate corolla-lobes and the former is a white-flowered form of *Gilia pulchella* Dougl.,* a species wholly omitted by Dr. Brand. Dr. Brand cited

* Hook. Fl. Bor.-Am. 2: 74. 1838.

two specimens under the forma *candida*, viz. *Nelson 4198* (should have been *4189*) and *Clements 13*. The former is a white-flowered form of *G. pulchella*, the latter belongs to *Gilia scariosa* Rydb. Dr. Brand did not notice the different structure of the calyx, which places *G. scariosa* close to *G. aggregata Bridgesii* A. Gray. Nelson in the New Manual has also confused things. *Gilia scariosa* is made a synonym of *G. aggregata* and *G. candida* of *G. attenuata*. He has also overlooked the characters of the calyx of *G. scariosa* and the rounded corolla-lobes of *G. candida*.

Gilia arizonica (Greene) Rydb.

Callisteris arizonica Greene, Leaflets 1: 160. 1905.
Gilia aggregata typica arizonica Brand, Pflanzenreich 4^{250}: 115. 1907.

Gilia tenuituba Rydb. sp. nov.

Biennial; stem about 3 dm. high, finely glandular-puberulent; leaves pinnatifid with narrowly linear, puberulent, cuspidate divisions; inflorescence a thyrsoid panicle, puberulent; flowers short-pedicelled; calyx campanulate, glandular-puberulent, distinctly scarious in the sinuses; teeth lance-subulate, cuspidate, longer than the tube; corolla flesh-colored, nearly 4 cm. long; tube slender, 1 mm. thick below and 2 mm. at the throat; lobes narrowly lanceolate, attenuate, nearly 1 cm. long; stamens unequally inserted far down the corolla-tube, included; style slender, about equaling the corolla-tube.

UTAH: Beaver City, 1877, *E. Palmer 329* (type, in herb. Columbia Univ.). This is also related to *G. aggregata*.

Gilia hutchinsifolia Rydb. sp. nov.

Gilia arenaria rubella Brand, Pflanzenreich 4^{250}: 103. 1907.

This differs from *G. arenaria* Benth. and *G. sinuata* Dougl. in the acute corolla-lobes and broad and again lobed divisions of the leaves. The description "*Caulis inferne* (*an morbo?*) *rufo-lanatus*," from which Dr. Brand adopted the varietal name, is wholly erroneous. The red coloring is simply grains of red sand adhering to the specimens. This is the reason of my not adopting the varietal name.

Gilia straminea Rydb. sp. nov.

Annual; stem 2–3 dm. high, glabrous, or rarely slightly glandular-puberulent above, straw-colored, simple below, with a few

almost erect branches above; basal leaves glabrous, firm, 1–2 cm. long, pinnately lobed, with lanceolate cuspidate-tipped lobes; stem-leaves sessile and partly clasping, lanceolate, sharply dentate with cuspidate teeth or entire; calyx-tube campanulate, 2 mm. long, somewhat scarious in the sinuses, sparingly glandular-puberulent; teeth subulate, 1 mm. long; corolla trumpet-shaped, 7–8 mm. long; tube nearly twice as long as the calyx; capsule exceeding the calyx; seeds 5 or 6 in each cell.

This is related to *G. sinuata*, but differs in the simple, straw-colored, essentially glabrous stem, the glabrous, pale green leaves, and the form and toothing of the stem-leaves.

UTAH: St. George, 1877, *E. Palmer 325*,* in part (type, in herb. Columbia Univ.); also *326*.

Dr. Brand reduced *Gilia Tweedyi* Rydb. to a variety of *G. minutiflora*, without having seen a specimen. I do not think that it is rational to do so, for in *G. Tweedyi* the pod is not 1-seeded, but bears 1–3, usually 2, seeds in each cell, i. e., it is 4-seeded. The plant is more closely related to *G. inconspicua*.

Dr. Brand made *Gilia Haydeni* A. Gray a variety of *G. subnuda* Torr., and gave *G. Crandallii* Rydb. as a synonym of this variety. Professor Nelson regarded *G. Crandallii* as the same as *G. subnuda* and gave *G. Haydeni* and *G. superba* Eastw. as varieties of the same. Both arrangements are incorrect. *G. superba* Eastw. is the typical *G. subnuda* Torr. characterized by the orange or scarlet corolla. In both *G. Haydeni* and *G. Crandallii* the corolla is rose-colored. They are quite distinct from *G. subnuda* and in my opinion distinct from each other.

Dr. Brand's treatment of *Leptodactylon pungens* (Torr.) Nutt. or *Gilia pungens* (Torr.) Benth. and its relatives is far from satisfactory. He divides it in two subspecies: subsp. A. *eu-pungens* and subsp. B. *Hallii* (*Gilia Hallii* Parish), which is a matter of taste, but he also divides the former in four varieties: a. *Hookeri* (Dougl.) Brand; b. *caespitosa* (Nutt.) Brand; c. *tenuiloba* (Parish) Brand; and d. *devestita* Brand.

The first variety is based on *Gilia Hookeri* Benth. To make this species a variety of *G. caespitosa* could be also passed over, as

* The same number in the herbarium of the New York Botanical Garden is entirely different, and belongs to *Gilia hutchinsifolia*. Maybe some mixing of the labels occurred.

a matter of taste, but Dr. Brand in his treatment usually meant by the variety *a* the typical form. If that is his intention here, he is wholly mistaken, for the type is not viscid. Torrey's type should be placed under his variety *b. caespitosa*, and is exactly like *Goodding 32* and *Parry 236* from Wyoming, which Dr. Brand also refers to that variety. In fact Dr. Brand seems not to know *Leptodactylum caespitosum* Nutt. (*Gilia pungens caespitosa* A. Gray), although he adopts this name for a variety which proves to be the original *G. pungens*. *Leptodactylon caespitosum* is amply distinct, not only by the characters given by Dr. Gray, but also by the 4-merous flowers and the stamens inserted in the tube. All the other species have 5-merous flowers. *Gilia Hookeri* is confined to the western slope and does not extend into Utah, Colorado, New Mexico, and Arizona, as stated by Dr. Brand. The following specimens are wrongly referred to it: *Elmer 502* is typical *G. pungens; Jones 1784* and *MacDougal 183* belong to *G. pungens squarrosa* A. Gray. The Matthews' specimens I have not seen, but I think they also are wrongly referred to it. Of the specimens cited under the variety *devestita*, all I have seen belong to typical *G. pungens*, some of them having slightly longer leaves than the type, but not all.

Leptodactylon brevifolium Rydb. sp. nov.

Suffruticose, branched perennial, 1–2 dm. high; stems puberulent and slightly glandular above; leaves 3–5 mm. long, glandular-puberulent or glabrate, 3–5-divided into subulate, acerose, ascending divisions; calyx about 8 mm. long, glandular-puberulent; teeth subulate-acerose, much shorter than the tube; corolla trumpet-shaped, about 15 mm. long; stamens inserted in the throat of the corolla.

This is related to *Leptodactylon pungens* (Torr.) Nutt. and *L. Hookeri* (Dougl.) Rydb. (*Phlox Hookeri* Dougl.; *Gilia Hookeri* Benth.) but has much shorter leaves. The habit and flower are more like the former, but the calyx and young foliage are more or less glandular, though not so copiously so as in the latter.

UTAH: Juniper Range, 1898, *Purpus 6306* (type, in U. S. Nat. Herb.; duplicate in herb. N. Y. Bot. Gard.); Cedar City, *M. E. Jones 5204a;* Montezuma Canyon, *Eastwood;* rocky hills on the San Juan, *Newberry*.

?COLORADO: Gunnison, Aug. 16, 1901, *Baker 830* (doubtful, without flower).

NEW MEXICO: Cedar Hill, San Juan County, *Standley 7998*.

WASHINGTON: Coulee City to Ephrata, June 1902, *Griffiths & Cotton 471*.

NEVADA: Panaca, *V. Bailey 1971*.

Dr. Brand excluded *Gilia caespitosa* A. Gray not only from the genus but also from the family. He makes the following remark: "Species foliis calcareo-glandulosis ab omnibus Polemoniaceis valde abhorret; fortasse Saxifragaceis attributa est."

The leaves are by no means "calcareo-glandulosis," but merely viscid-pubescent as described by Dr. Gray. In the type they are covered by grains of sand, that is all. It is without doubt a species of *Gilia* and probably, as Dr. Gray suggested, related to *G. subnuda*, but as the corolla was unknown the placing in the genus was uncertain. One thing is certain, it should not be placed next to *G. rigidula* as it is in the Synoptical Flora. The duplicate of the type in the National Herbarium bears a single withered and partly torn corolla; this is trumpet-shaped and about 1 cm. long; the real structure is not possible to make out, but the plant is probably related to *G. subnuda*.

Dr. Brand gives *Micranthes diffusa* as a synonym under *Gilia gracilis* subspecies *humulis* var. *micrantha*, while he cites *Heller 3098* (its type) under *G. gracilis* subsp. *eu-gracilis* var. *eritrichoides*, which shows carelessness in identifying the different forms described. In the Columbia University herbarium there is a duplicate of Douglas's collection, which shows that Brand's var. *eritrichoides* is the typical form of *Microsteris gracilis* (Dougl.) Greene.

Dr. Gray in his Synoptical Flora* segregated out *Gilia aristella* from material he had previously included in *Collomia linearis subulata*. The latter he regarded as the same as *Collomia tinctoria* Kellogg. Notwithstanding this judgment of Dr. Gray, which always will weigh considerably, Dr. Brand made *Collomia aristella* (A. Gray) Rydb. a synonym of *C. tinctoria* Kellogg, while he named *C. tinctoria subulata* (A. Gray) Brand from Gray's variety *C.*

* 2[1]: Suppl. 408. 1886.

linearis subulata. Dr. Brand did not give any reason for this change. Furthermore, he did not cite any specimens of his *C. tinctoria* from California and I have seen no specimens of *C. aristella* from that state. Of the variety *subulata*, on the contrary, there are several collections from California in our herbaria. There is nothing either in Kellogg's description or in his figure which would indicate that Dr. Gray had made a misinterpretation. Kellogg's figure is drawn from a young, simple, undeveloped plant, and the peculiar branching of the var. *subulata* in age does not show. Whether *C. tinctoria* and *C. aristella* should be united into one species is another question, but in such a case the variety *subulata* should have been made the species, viz., *C. tinctoria* Kellogg, and *C. aristella* a variety thereof; and this for the following reason: The variety *subulata* is certainly found in the type region of *Collomia tinctoria*, while *C. aristella* apparently is not. Seen from another standpoint, the local and more specialized *C. aristella* must be regarded as the derivative of the more common and less specialized *C. tinctoria* (i. e., the var. *subulata*).

Brand transferred *Gilia sinister* M. E. Jones to *Collomia* without having seen the plant. This was probably because Mr. Jones placed it in the *Collomia* section and compared it with *G. aristella*. But Jones also made the following statement: "This has the general appearance of *G. inconspicua*, but without the basal leaves." The relationship is also with *G. inconspicua*. Several of the species of that group have the calyx enlarged somewhat in fruit; this is true in *G. sinister*, but it is at last ruptured by the capsule and does not have the structure of the calyx in *Collomia*. It is in my opinion a true *Gilia*.

Dr. Brand included a number of forms, in my judgment several good species, under *Polemonium pulcherrimum* Hook. He divides it in three subspecies, *tricolor*, *delicatum*, and *parvifolium*. The first is separated by its tricolored flowers and equals *P. tricolor* Eastw. The other two subspecies he separated only by the length of the leaflets, a very poor character to use for separating subspecies.* He overlooked the fact that in all these forms included

* Under var. *Haydenii* Dr. Brand made the following remarks: "The forms from the southern Rocky Mountains, which could be counted to this, are better to be regarded as depauperate forms of subsp. *delicatum*."

in the subspecies *delicatum*, the stem is pubescent with long white spreading hairs and the leaflets are decidedly acute, while in the forms included in the subspecies *parvifolium*, the stem is merely puberulent and the leaflets usually obtuse.

The specimens cited under the subspecies *delicatum* belong to three or four different species. Those from Colorado and Utah belong to *P. scopulinum* Greene and *P. delicatum* Rydb., which perhaps may not be specifically distinct. Those from California belong to *P. californicum* Eastw. Those from Washington and perhaps those from Oregon to an undescribed species, characterized below.

The subspecies *parvifolium* was divided in var. α *Haydenii* and var. β *pilosum* (= *P. pilosum* Greenman). It is very hard to interpret Dr. Brand's arrangement. He gives under the subspecies *parvifolium* the following synonyms: *P. parvifolium* Nutt.; *P. coeruleum* J. Hook.; *P. mexicanum* Nutt.; *P. viscosum* A. Gray, not Nutt., but cited no specimens. His usage as well as that of most European botanists is to designate the typical form by var. α. Hence var. α *Haydenii* is the typical form of subsp. *parvifolium*, and still under this he has the following synonyms: *P. Haydeni* A. Nels., *P. montrosense* A. Nels., and *P. Tevisii* Eastw. *P. parvifolium* Nutt. is the same as *P. mexicanum* Nutt. and *P. viscosum* A. Gray, and is characterized by its small dense inflorescence and its obtuse calyx-lobes, or the latter even rounded at the apex; but it is not the same as *P. coeruleum* γ Hook., or *P. Haydeni* A. Nels., or *P. Tevisii* Eastw.

Polemonium coeruleum γ Hook. is the original *P. pulcherrimum* Hook., and this should have been made subsp. A var α, according to Brand's system. *P. Haydeni* resembles it closely in flowers, leaves and pubescence, but differs considerably in general habit and the inflorescence.

Polemonium columbianum Rydb. sp. nov.

Perennial, with a branched rootstock and caudex; stems several, 2–3 dm. high, viscid-pubescent with flattened hairs, and distinctly glandular in the inflorescence; leaves 5–15 cm. long, likewise sparingly viscid-pubescent, pinnate; leaflets 9–19, elliptic or lance-elliptic, acute, 1.5–3 cm. long; inflorescence corymbiform-paniculate; calyx about 6 mm. long, glandular-puberulent and

pubescent; lobes lanceolate, acute, fully equaling the tube; corolla 10–12 mm. long, open-campanulate, violet with yellowish base; lobes rounded-truncate at the apex; stamens two thirds to three fourths as long as style and slightly longer than the corolla.

This resembles *P. scopulinum* Greene in habit, but is a larger plant with much larger flowers. It grows in the mountains of Idaho and Washington at an altitude of 1,500–2,000 m.

IDAHO: Divide between St. Joseph and Clearwater Rivers, July 9, 1896, *Leiberg 1205* (type, in herb. N. Y. Bot. Gard.); Wiesner's Peak, July 8, 1892, *Sandberg, MacDougal & Heller 1049.*

WASHINGTON: Wenatchee Mountains, July, 1897, *Elmer 456;* Goat Mountain, Aug. 12, 1896, *Allen 262;* Clallam, July, 1900, *Elmer 2819;* Palace Camp, 1883, *Mrs. Bailey Willis.*

Polemonium intermedium (Brand) Rydb. sp. nov.

Polemonium occidentale intermedium Brand, Pflanzenreich 4^{250}: 33. 1907.

This I think is well worth specific rank. It is confined to the Columbia River region of Idaho, Washington, and British Columbia.

Dr. Brand regarded *Polemonium speciosum* Rydb. as a good species. Professor Nelson on the other hand makes it a variety of *P. mellitum* (A. Gray) A. Nels., which is evidently erroneous. If it should be made a variety of any of the verticillate species of *Polemonium*, it should have been of *P. viscosum* Nutt. or rather of *P. Grayanum* Rydb., which species Professor Nelson does not regard as distinct. *P. speciosum* has a short blue corolla and subcapitate inflorescence.

HYDROLEACEAE

Hydrophyllum Watsonii (A. Gray) Rydb. sp. nov.

Hydrophyllum occidentale Watsonii A. Gray, Proc. Am. Acad. 10: 314. 1875.

Miltitzia foliosa (Jones) Rydb.

Emmenanthe foliosa M. E. Jones, Zoe 4: 278. 1893.

The *Miltitzia* section of *Emmenanthe* of Gray's Synoptical Flora, I think is generically distinct from *Emmenanthe* proper,

and DeCandolle's genus *Miltitzia* should be restored. The latter genus is represented in the Rocky Mountain region by this and the two following species.

Miltitzia salina (A. Nels.) Rydb.

Emmenanthe salina A. Nels. Bull. Torrey Club **25**: 381. 1898.

Miltitzia scopulina (A. Nels.) Rydb.

Emmenanthe scopulina A. Nels. Bull. Torrey Club **25**: 380. 1898.

Phacelia orbicularis Rydb. sp. nov.

Biennial or annual; stems 1–2 dm. high, glandular-villous, often tinged with red, branched; leaves petioled; blades suborbicular in outline, crenately lobed, 1.5–2.5 cm. long, hirsute as well as glandular; racemes many-flowered; calyx-lobes oblong or oblanceolate, obtuse, 3 mm. long; corolla purplish, 6 mm. long, campanulate-funnelform; lobes crenulate; filaments about twice as long as the corolla; seeds faveolate, crenately lobed on the margins and the median ridge.

This is related to *P. integrifolia*, but the plant is smaller and the leaf-blades shorter and broader.

UTAH: Marvin Laccelite, 1894, *M. E. Jones 5663* (type, in U. S. Nat. Herb.).

Phacelia crenulata Torr., *P. bicolor* Torr., *P. affinis* A. Gray, *P. glechomaefolia* A. Gray, *P. hispida* A. Gray, *P. humilis* T. & G., *P. demissa* A. Gray, *P. Palmeri* Torr. (not *P. Palmeri* Vasey & Rose), *P. pinetorum* Jones, and *P. pusilla* Torr. have been collected in Utah; *P. glandulifera* Piper and *P. ramosissima* Dougl., in Idaho. I cannot distinguish *P. luteopurpurea* A. Nels. from *P. glandulifera* Piper. *Capnorea incana* Greene, *C. nana* (Lindl.) Raf., *C. nervosa* Greene, and *C. Watsoniana* Greene have been collected in Idaho; the first one also in Montana and the last one in Wyoming; *Emmenanthe penduliflora* Benth. and *Eriodictyon angustifolium* Nutt. in Utah.

BORAGINACEAE

Gruvelia setosa (A. Gray) Rydb.

Pectocarya setosa A. Gray, Proc. Am. Acad. **12**: 81. 1877.

I think that the genus *Gruvelia* A. DC. should be restored, being quite distinct from *Pectocarya*. The only other species is *G. pusilla* A. DC., the type of the genus.

Professor Nelson both in the original diagnosis* and in Coulter & Nelson's New Manual† described *Lappula erecta* as having the marginal prickles in a single row, but a duplicate of the type in the Columbia University herbarium and all specimens distributed as *Lappula erecta* by Professor Nelson himself in the herbarium of the New York Botanical Garden have a double row of marginal prickles, the prickles of the outer row being somewhat smaller than those of the inner.

Oreocarya pustulosa Rydb. sp. nov.

Perennial, branched at the base; stems 3–5 dm. high, glabrous or nearly so throughout, lower leaves linear-oblanceolate, the upper linear or linear-lanceolate, 3–10 cm. long, green, glabrous beneath, sparingly hairy above; the hairs short and at least in age with conspicuous pustulate bases; flowers paniculate; branches racemose, not secund; pedicels 1–2 mm. long; sepals triangular-lanceolate, acute; corolla white; tube not exceeding the calyx; limb 5–6 mm. broad; lobes orbicular; fruit depressed-globose; nutlets smooth, nearly white, mottled with light brown, more or less separated from each other on the margins, often not all maturing.

This is related to *Oreocarya multicaulis* (Torr.) Greene, *O. suffruticosa* (Torr.) Greene and the Mexican *O. Palmeri* Greene. It differs from the first two in the glabrous stem, green leaves, and light nutlets, and from *O. Palmeri* in broader leaves and different habit. It grows in canyons at an altitude of 1,700–2,000 m.

UTAH: Hammond Canyon, Elk Mountains, July 31, 1911, *Rydberg & Garrett 9320* (type, in herb. N. Y. Bot. Gard.); also same locality, Aug. 9, 1911, *9569;* Dry Wash, southwest of Abajo Mountains, August 10, *9590.*

Oreocarya Macounii Eastw. sp. nov.

Biennial or perennial with a slender tap-root; stem slender, 1–2 dm. high, sparingly hirsute; leaves narrowly linear or narrowly linear-oblanceolate, sparingly hirsute; inflorescence racemiform with short branches; corolla white, 5 mm. long, 4 mm. wide; nutlets ovate, obtuse, 2 mm. long, acutely margined, rounded on the back and coarsely muricate.

SASKATCHEWAN: Moose Mountain Creek, July 6, 1880, *John*

* Bull. Torrey Club 27: 268. 1900.

† 412. 1909.

Macoun; also a specimen from Hooker's herbarium without date, probably collected by Richardson, at Carlton House. (Both in herb. Columbia University.)

Cryptanthe flexuosa A. Nelson is, I think, the same as *C. calycosa* (A. Gray) Rydb., and *C. muriculata montana* A. Nels. should be referred to *C. ambigua* (A. Gray) Greene, and *C. Hillmani* A. Nels. to *C. Watsoni* (A. Gray) Greene. *C. flaccida* (A. Gray) Greene has been collected in Idaho; *C. recurvata* Coville, in Utah and Colorado.

Mertensia coriacea A. Nels. is the same as *M. lanceolata* Pursh. Professor Nelson gives the range of *M. lanceolata* as Colorado and Wyoming. The type came from western Montana. *M. perplexa* is not the same as *M. coriacea*, as stated by Professor Nelson, but belongs to the *M. alpina* group with subsessile anthers.

Anchusa officinalis L. and *Asperugo procumbens* L. have been collected in Colorado; *Plagiobotrys arizonicus* (Gray) Greene in Utah; *P. tenellus* A. Gray in Idaho; *Cynoglossum officinale* L. in Wyoming and Montana; *Eremocarya muricata* Rydb. in Utah; *Lithospermum arvense* L. in Utah; *Mertensia brachycalyx* Piper in Idaho; *M. pulchella* Piper, *M. nutans* Howell, and *M. longiflora* Greene in Idaho and Montana; *Amsinckia hispidissima* Suksd., *A. retrorsa* Suksd. and *A. micrantha* Suksd. have been collected in Idaho.

Pectocarya miser A. Nels. I can not distinguish from *P. penicillata* (H. & A.) A. DC. *Eddya hispidissima* Torrey has been collected in Utah.

VERBENACEAE

Verbena remota Benth. was collected in southeastern Utah in 1911 by Professor Garrett and myself. *Verbena bipinnatifida* Nutt. is very rare in the region and *V. canadensis* (L.) Britton does not occur at all. The range given in Coulter & Nelson's New Manual is erroneous. The group is represented in the Rocky Mountains by *V. ambrosifolia* Rydb., *V. Gooddingii* Briq., and *V. ciliata* Benth.

LAMIACEAE

Lamium amplexicaule L. has been collected in Colorado; *Micromeria Douglasii* Benth. and *Trichostoma oblongum* Benth., in Idaho.

Monarda Nuttallii A. Nels. or *M. citriodora* of Coulter's Manual is *Monarda pectinata* Nutt.

Salvia Columbariae Benth. has been collected in Utah.

SCROPHULARIACEAE

Miss Eastwood has called to my attention that *Pentstemon acuminatus*, *P. humilis* Nutt., and *P. glaucus* Graham have been misinterpreted. *P. acuminatus* is a species confined to the Columbia Valley, has a more ample corolla, perfectly glabrous within; the tongue of the sterile filament is strongly curved and only short-bearded at the apex. Whether the so-called *P. acuminatus* of the Rocky Mountain region is a distinct species or should be included in *P. nitidus* Dougl. is hard to tell. A duplicate of the type of the latter is in the Columbia University herbarium, but this, as well as several other specimens, does not have the broad, abruptly acuminate bracts, characteristic of the so-called *P. acuminatus*, but there is no other distinction and intermediate forms are not lacking.

The original *P. humilis* Nutt. is, according to Miss Eastwood, the same as *P. collinus* A. Nels., which therefore passes into synonymy. Dr. Gray in describing *P. humilis** makes Nuttall's plant the type, but evidently had another plant mostly in his mind, viz. *Parry 257* and from this we have received our usual idea of *P. humilis*. This probably should be known as *P. albertinus* Greene,† which apparently is the same. Professor Nelson gives *P. pseudohumilis* Rydb. as a synonym, but this is the same as his own *P. Owenii*.

Pentstemon glaucus Graham does not belong to the group where Dr. Gray placed it and has nothing to do with the Rocky Mountain plant *P. stenosepalus* (Gray) Howell (*P. glaucus stenosepalus* A. Gray), but belongs to the *P. confertus* group. It is evidently the same as *P. pinetorum* Piper or closely related to it.

Pentstemon Macbridei A. Nels.‡ and *P. perpulcher* A. Nels. are apparently *P. Cusickii* A. Gray and *P. unilateralis* Rydb., respectively. A duplicate of the type of *P. Cusickii* is in the herbarium

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* Proc. Am. Acad. 6: 69. 1862.

† Leaflets 1: 167. 1906.

‡ Bot. Gaz. 52: 272, 273. 1911.

of Columbia University. The type of *P. unilateralis* is in that of the New York Botanical Garden. Recently botanists have overlooked the fact that in *P. speciosus* the anthers are perfectly glabrous and not short-bearded as in *P. glaber*. Dr. Gray overlooked the fact that *Pentstemon humilis* Nuttall is a member of the *P. erianthera* group and closely related to *P. miser* A. Gray, and placed it near *P. caespitosus* Nutt. Gray's two varieties of *P. humilis*, however, have nothing to do with it, and belong to the *P. caespitosus* group. The variety *Thompsoniae* has been already raised to specific rank and var. *incanus* is probably a form of it.

Pentstemon Leonardi Rydb. sp. nov.

Low perennial, suffruticose at the base; stems 1–2 dm. high, leafy, glabrous or minutely puberulent; leaves oblanceolate, 2–4 cm. long, short-petioled, glabrous; inflorescence short and often somewhat secund; calyx glabrous, about 6 mm. long; lobes lanceolate, acuminate, not scarious-margined; corolla 12–15 mm. long, rose-purple, only slightly ampliate, glabrous within; anthers horseshoe-shaped, saccate, opening only on the proximal one third, hispidulous on the margins of the pores, otherwise glabrous.

This belongs to the *P. azureus* group and has been confused with *P. Kingii*, but the leaves are broader and glabrous, the corolla less ampliate, the sepals not glandular and more acuminate. It differs from *P. platyphyllus* in the low habit and the smaller oblanceolate leaves.

UTAH: Diehl's Grove, Wahsatch Mountains, Aug. 1, 1884, *Leonard* (type, in herb. N. Y. Bot. Gard.); Deer Creek, *M. E. Jones;* Wahsatch Mountains, July, 1888, *J. H. Paul;* Central Utah 1875, *Parry 72.*

IDAHO: Franklin Basin, Bear River Range, July 24, 1910, *C. P. Smith 2278.*

Mimulus Eastwoodiae Rydb. sp. nov.:

Mimulus cardinalis Eastw. Bull. Calif. Acad. II. 6: 312. 1896.

Not *M. cardinalis* Dougl. 1842.

Perennial, with rootstock and stolons; stem 1–2 dm. long, viscid-villous; leaves sessile, coarsely dentate, viscid-villous, 3–5-ribbed, sessile, 2–5 cm. long, the lower cuneate and truncate, the upper obovate or broadly oblanceolate and acute; stolons 1–3 cm. long, rooting at the end and nodes; their leaves less than 1 cm.

long; flowers mostly solitary; pedicels 1–4 cm. long; calyx narrowly funnelform, strongly 5-angled; lobes nearly equal, lanceolate, about half as long as the tube; corolla crimson, 3–4 cm. long, scarcely ventricose; anthers sparingly bearded.

This is related to *Mimulus cardinalis*, to which Miss Eastwood referred it with some hesitation. She also pointed out the low habit and more sharply toothed leaves, but did not notice the most striking feature of the plant, viz., its stolons, which are sent out after blooming. By means of these the plant, growing as it does in crevices of perpendicular or overhanging cliffs, can propagate itself in every direction. Wherever a stolon touches the rock and the root can get a foothold, a new plant is formed, even under the overhanging rocks. In the latter case the plantlet formed will be growing, the following year, with the roots up and the flowers down.

UTAH: In cervices of perpendicular or overhanging rocks, along San Juan River, near Bluffs, August 25–29, 1911, *Rydberg 9883* (type); also the same locality, *Miss Eastwood*.

Veronica Buxbaumii Tenore has been collected in Utah and *V. arvensis* L. in Idaho. *Veronica peregrina* L. is not found in the Rocky Mountain region. All specimens so named from there belong to *V. xalapensis* H. B. K. *Antirrhinum Cooperi* A. Gray and *A. Kingii* S. Wats. have both been collected in Utah; *Moniera rotundifolia* Michx. in Montana; *Gratiola ebracteata* Benth. in Montana and Idaho.

Triphysaria hispida (Benth.) Rydb.

Orthocarpus hispidus Benth. Scroph. Ind. 13. 1835.

In the genus *Cordylanthus* [*Adenostegia*] Coulter & Nelson* have transposed the color characters of the corolla of *C. Wrightii* and *C. ramosa*. *Adenostegia capitata* (Nutt.) Greene has been collected in Idaho and *A. canescens* is common around Great Salt Lake. *Cordylanthus bicolor* A. Nels. is evidently the same as *Adenostegia ciliosa* Rydb.

Castilleja subcinerea Rydb. sp. nov.

Perennial with a branched short caudex; stems 3–5 dm. high, canescent-strigose, stout; leaves more or less canescent, strongly

* See Manual 462. 1909.

3-ribbed, 5–7 cm. long, the lowest entire, linear, the upper 3-cleft; bracts broadly cuneate in outline, 5–7-cleft, canescent, the lower grayish green, the upper tinged with yellow and often brown-tipped; calyx canescent, 2.5 cm. long, equally cleft above and below, each lobe 2-cleft; corolla greenish yellow; upper lip 9 mm. long; the lower about 3.5 mm. long, slightly saccate.

It may be related to the *C. hispida* group, but the plant is grayish strigose, and the bracts yellow-tinged.

IDAHO: Beaver Canyon, June 28, 1895, *C. L. Shear 3041* (type, in herb. N. Y. Bot. Gard.); also *3038;* mountains near Indian Creek, July 21, 1897, *Rydberg & Bessey 4969* (at least in part).

Euphrasia mollis (Ledeb.) Wettst. has been collected in Montana; *Pedicularis lanata* Willd. and *P. flammea* L. in the Canadian Rockies; *P. Oederi* Vahl in Montana and *P. centranthera* A. Gray in Utah and Colorado.

OROBANCHACEAE

Thalesia purpurea Heller, *T. minuta* (Suskd.) Rydb. and *T. Sedi* (Suksd.) Rydb. have been collected in Montana and northern Idaho, and *Myzorrhiza pinetorum* (Geyer) Rydb. in Idaho.

LOBELIACEAE

Howellia aquatilis A. Gray and *Heterocodon rariflorum* Nutt. have been collected in Idaho and *Nemacladus ramosissimus* Nutt. in south Utah.

NEW YORK BOTANICAL GARDEN.

Observations on the geographical composition of the Sugar Grove flora *

ROBERT F. GRIGGS

The Sugar Grove area is one of those places which are sometimes found where the botanical interest of a large region may be said to come to a focus. Not only do the plant associations, both upland and lowland, characteristic of eastern Ohio reach their climax here as nowhere else but about one plant in eight of the native flora, nearly one hundred and twenty in all, reaches here the edge of its range. These include species stretching away in every direction, north, south, east, and west. A study of the ranges of these plants shows that the area is the key to an understanding of the plant geography of Ohio.

This region is a narrow strip of very rough and rugged sandstone country extending from near the town of Sugar Grove, Fairfield Co., Ohio, southward for about twenty miles to the canyon of Queer Creek east of South Bloomingville, Hocking Co. Its position is roughly indicated by an ellipse in FIGURES 1, 2. It is located at the end of the long lobe of the Alleghenian floral area which Merriam's† map shows stretching into northeastern Ohio, a location which of itself marks it as an interesting region. It has been long known as an exceedingly rich collecting ground and contains an unusual number of rare plants not found elsewhere in Ohio.

In most of the published work on plant geography the area considered is divided into zones which are plotted on the map. Although the boundary lines of the zones are always difficult to settle, this method reaches results satisfactory to the geographer, who is primarily interested in subdividing the area of the earth. Not so however to the botanist, who is interested in plants rather

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* Contribution from the Botanical Laboratory of the Ohio State University No. 75.

† Merriam, C. Hart. Life zones and crop zones. U. S. Dept. Agr. Biol. Survey Bull. 10. 1898.

than in areas. For by this method no locality can be possibly assigned to more than two zones whereas the flora of most regions is composed of numerous groups of plants of diverse affinities. The adequate representation of these requires not one but many maps each portraying a typical range. In the present paper an attempt is made to treat the Sugar Grove flora in this fashion.*

It is however very difficult to secure the data necessary for a consideration of plant ranges and the results are necessarily crude in consequence. There has been as yet almost no exact research into the ranges of North American plants. Only in the case of a few specially interesting species has any great effort been made to ascertain the facts of distribution. The ranges assigned to our plants in the manuals, even the most careful of them, are to a considerable extent the result of tradition and guesswork and are frequently far from accurate, while in works like Hough's Trees, which is almost the only general work that has attempted to map ranges, the maps given are so inaccurate as to be almost useless for detailed work. The importance of reliable data of this sort may be brought out by an example. The chestnut, *Castanea dentata*, whose distribution is much talked of just now in estimates of the probable damage to be expected from the chestnut blight, *Endothia parasitica*, is usually given† as occurring over all of Ohio except the extreme northwest corner and much of Indiana. But in reality‡ it is confined to the vicinity of the Lake Shore around the western end of Lake Erie, is entirely absent from western Ohio but occupies eastern Ohio and stretches through the southern part of the state into southern Indiana—thus lessening the area susceptible to damage by the blight by something more than 10,000 square miles.

The labor involved in determining accurately the range of a single plant is not inconsiderable. There is not a single herbarium

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* For his conception of this point of view and for the ideas which are stimulated and exchanged during many friendly discussions as well as for more specific suggestions the writer is very greatly indebted to Professor M. L. Fernald of the Gray Herbarium. For a discussion of the flora of Newfoundland from this point of view see his "Botanical Expedition to Newfoundland and Southern Labrador," Rhodora 13: 135–162. 1911.

† See map opp. p. 28 in Rep. Pennsylvania Chestnut Blight Conference. Harrisburg. 1912.

‡ See map opp. p. 180, l. c.

in the country large enough in itself to supply the data for a rough approximation of the range of even our better known species. He who would accumulate information of this sort must visit half a dozen herbaria to get even a general view of the ranges of our common plants. Recourse must also be had to numerous local floras, where such are available, and the correctness of their identifications must be taken on faith. Moreover even our best known species have not been collected enough as yet to supply

FIG. 1. Distribution of *Lycopodium* in Ohio.

1. *L. clavatum.*
2. *L. complanatum.*
3. *L. inundatum.*
4. *L. lucidulum.*
5. *L. lucidulum porophilum.*
6. *L. obscurum.*

satisfactory data as to their distribution and there are still hundreds of species the very characters of which are not yet understood.

The difficulty of getting adequate data for such work at present may be illustrated from Fernald's careful paper cited above, in which *Thuja occidentalis* is mapped as barely reaching Ohio whereas it occurs over the central and south central part of the state as far as Delaware, Champaign, and Highland counties; *Aster macrophyllus* likewise is found over northeastern Ohio to Hocking county, although it is given as barely touching the northeastern corner of the state. These illustrations are not cited in any spirit of criticism but at once to call attention to the importance of *local* work of this sort, and to forestall criticism of the maps given herewith, which are probably equally faulty.

It has seemed wise not to indicate the edges of the ranges but rather to show known stations. Those stations from which the writer has seen a specimen are marked with a "bullseye" while those which were compiled from the literature are marked by a circle without the central dot. The maps are thus capable of indefinite extension as more stations are found or more specimens seen.

Fortunately for the purposes of this paper we have in the state of Ohio, thanks to the energy and enthusiasm of the late Dr. W. A. Kellerman, a very representative state herbarium which is indexed by counties after the fashion of the state maps herewith reproduced. Although by no means complete as yet these maps enable one to learn relatively accurately the distribution of the flora over the state simply by glancing at the index. Curiously enough the distribution in Ohio often gives almost no clue as to the range of a species. Thus *Populus heterophylla* is confined to the northern half of Ohio but in Indiana it is confined to the southern portion! On further examination its range is found to be the Atlantic coastal plain from southern Connecticut around the Gulf coast and up the Mississippi and Wabash River systems to the basin of Lake Erie.

One's general expectation concerning plant distribution is, that being controlled by climate, the termini of the ranges follow the parallels of latitude in a general way, crossing the state from

east to west. In Ohio, however, the reverse is the case; most of the termini run in north and south lines. As one examines the card catalog he soon finds several types of distribution that are of frequent occurrence. By far the most common of these covers

OHIO

FIG. 2. Range of *Oxydendrum arboreum* in Ohio.

the northeastern quarter of the state extending south to the present area along the lines of Merriam's map. This may be illustrated by the distribution of *Lycopodium* in Ohio (FIG. 1). Almost as conspicuous is a second group which extends north from the Ohio River and occupies a triangular area with its apex at Sugar Grove. The sorrel-tree, *Oxydendrum arboreum*, is a typical example (FIG. 2).

Each of these when the whole range of the plants concerned is taken into consideration is found to be a composite of several types of distribution. These together with others belonging to types not so conspicuously homogeneous within the state may be classified as follows:

A. ALLEGHENIAN PLANTS ON THE SOUTHWESTERN EDGES OF THEIR RANGES.

Type range, BETULA LUTEA (FIG. 3).

FIG. 3. Range of *Betula lutea*.

This list includes beside the Alleghenian plants which go no further west than the Lake Superior region, some Canadian plants which stretch across the continent. Though these are more northerly and fewer of them reach Ohio, the ranges of those that we do have are so similar to the Allegheny type that they are inseparable. *Capnoides sempervirens* (FIG. 4) and *Cornus canadensis*, which terminates about twenty miles north of our area, are typical examples. Although this is a very homogeneous group of plants, conforming very closely to the typical range, many of them are also found in outlying stations far removed from the main range, as for example *Blephariglottis lacera* and *Tsuga canadensis*. There is also a tendency which may become more evident when more collections are available, for some of them to extend into southwestern Ohio and southern Indiana, e. g. the chestnut. This list includes 39 species as follows:

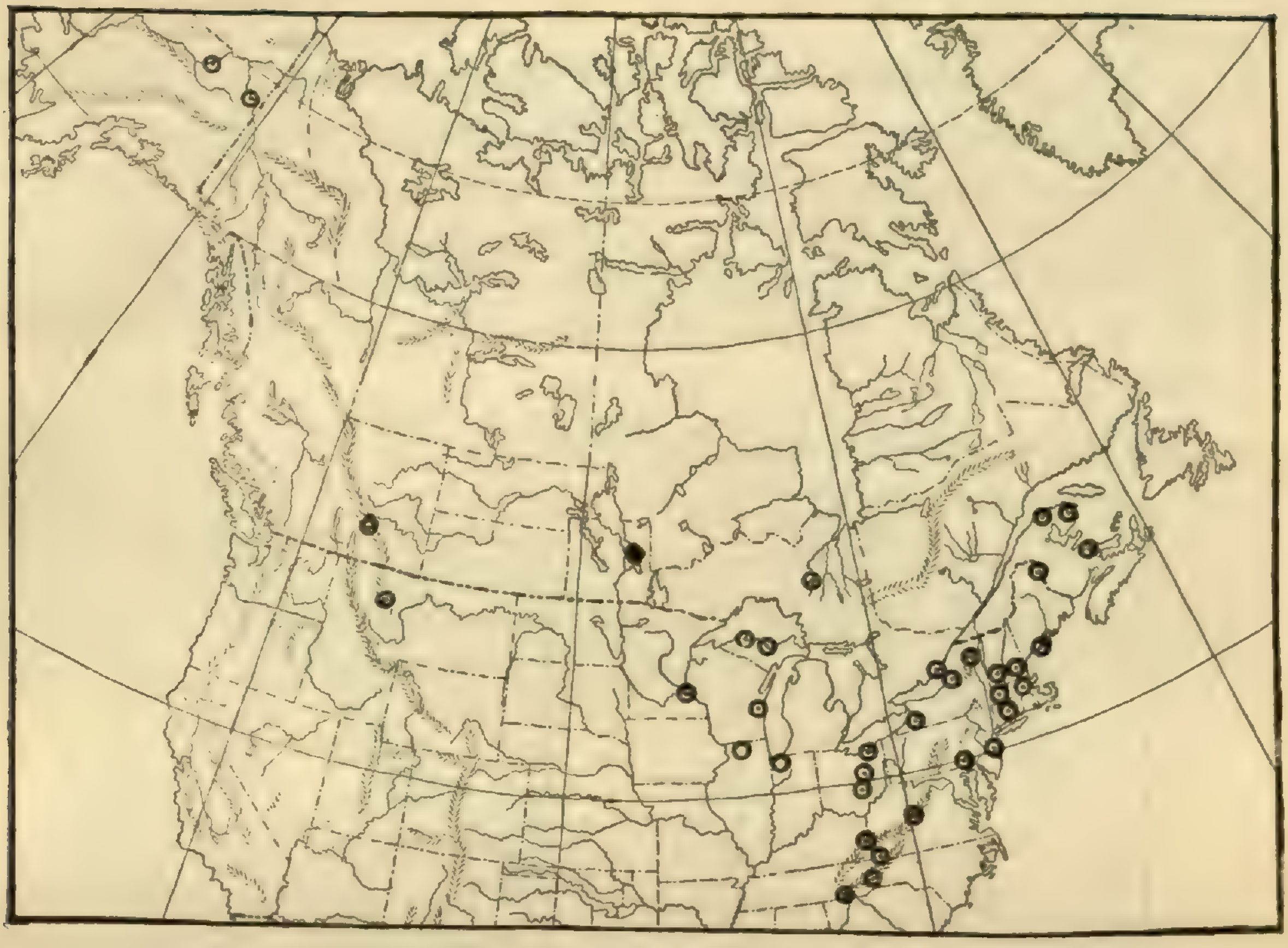

FIG. 4. Range of *Capnoides sempervirens*.

Achroanthes unifolia
Aronia nigra
Aster macrophyllus
Betula lutea
Blephariglottis lacera
Capnoides sempervirens
Chimaphila maculata
Chrysosplenium americanum
Circaea alpina
Cypripedium acaule
Cypripedium reginae
Epigaea repens
*Fraxinus nigra**
Gaultheria procumbens
Gentiana crinita
Isotria verticillata
Juncoides s altuensis
Lycopodium clavatum
Lycopodium complanatum
Lycopodium lucidulum
Lycopodium lucidulum porophilum
Lycopodium obscurum
Lysias orbiculata
Lysimachia quadrifolia
Melampyrum lineare
Panicularia elongata
Panicularia pallida
Parnassia caroliniana
Polygonum arifolium†
Pyrola elliptica
Pyrola rotundifolia

* The Ohio and Indiana (fide Coulter) distribution would indicate that this belongs in group F, but I follow Hough's map and place it here. It is unknown south of Columbus.

† Too widely extended in Indiana and Georgia to be typical.

Rubus odoratus
Rynchospora glomerata
Sambucus pubens
Saxifraga virginiensis
Trollius laxus
Tsuga canadensis
Unifolium canadense
Viola rostrata.

B. APPALACHIAN AND NEW ENGLAND SPECIES ON THE WESTERN EDGES OF THEIR RANGES (reaching Maine but not extending west of Lake Erie).

Type range, SERICOCARPUS ASTEROIDES (FIG. 5).

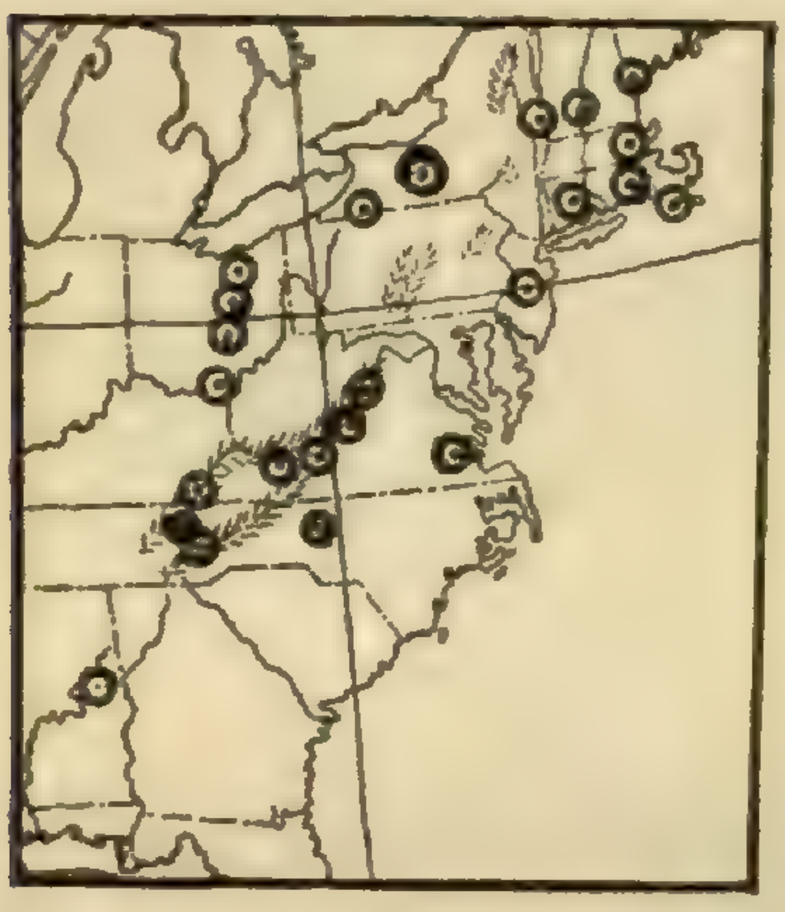

FIG. 5. Range of *Sericocarpus asteroides.*

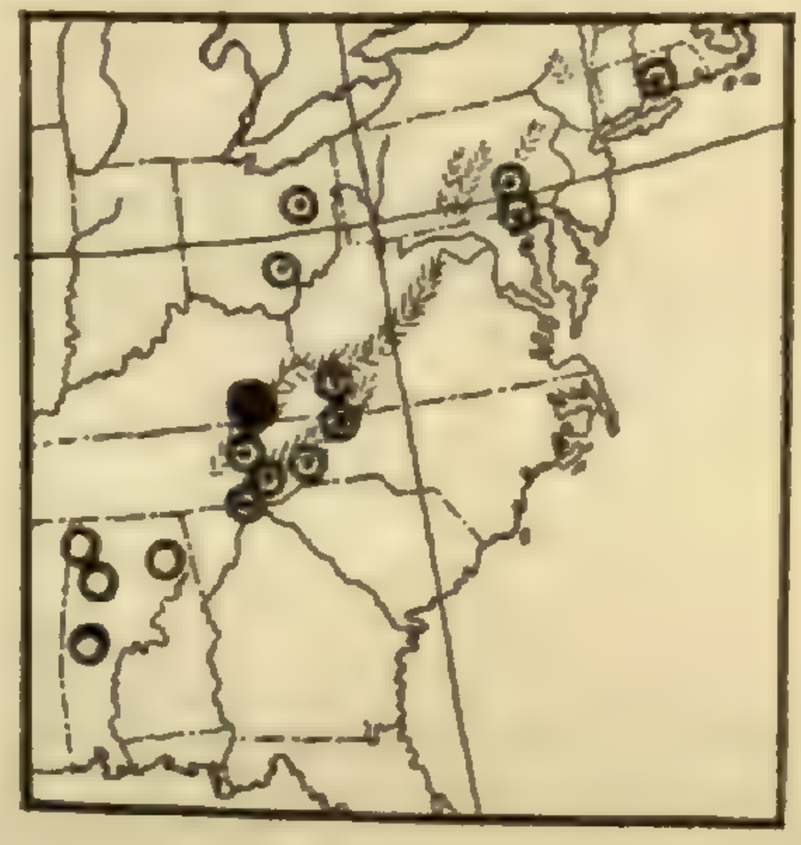

FIG. 6. Range of *Asplenium montanum.*

The lines separating this group of plants from the preceding and following categories are somewhat arbitrary. There are many plants of evident boreal affinities which are now confined to the Appalachians. Their ranges form a continuous series between the typical Alleghenian, extending from Newfoundland to Lake Superior, down to those like *Abies Fraseri* and *Tsuga caroliniana* which are confined to a small area in the highest part of the southern mountains. Those which reach Ohio, however, seem to fall rather naturally into the two categories here listed. Those of the first group number 14 and include:

Aster divaricatus
Carex costellata
Castanea dentata
Dasystoma laevigata
Eatonia nitida
Hieracium paniculatum
Hieracium venosum
Kalmia latifolia
Panicularia acutiflora
Pinus rigida
Quercus Prinus
Rhododendron maximum
Sericocarpus asteroides
Viola rotundifolia.

C. APPALACHIAN PLANTS (from southern New York or Connecticut to Ohio and south through the mountains).

Type range, ASPLENIUM MONTANUM (FIG. 6).

These ranges are in some cases difficult to distinguish from those of the Carolinian plants because their northern boundaries nearly coincide and because of the tendency to spread through southern Ohio into Indiana toward the Ozarks. In such cases the general affinities of the plant have been the criterion for decision. Thus *Aruncus Aruncus* is placed here because the same or a closely related species is found on the Pacific coast to Alaska thereby clearly indicating its boreal affinities although its distribution in the eastern United States is apparently clearly Carolinian. We have 12 plants belonging to this category as follows:

Aruncus Aruncus
Asplenium montanum
Asplenium pinnatifidum
Azalea lutea
Cardamine rotundifolia
Oxydendrum arboreum
Phlox stolonifera
Phacelia dubia
Pinus virginiana
Silene rotundifolia
Stachys cordata
Viola hirsutula.

D. CAROLINIAN PLANTS ON THE NORTHERN EDGES OF THEIR RANGES.

Type range, PASSIFLORA LUTEA (FIG. 7).

These are typically plants of southern or even subtropical affinity whose northern limits are largely determined by latitude. As might be expected, there is no such uniformity in the northern ranges of these plants as in those of the first group; *Ilex opaca*, *Quercus marylandica*, and *Liquidamber Styraciflua*, though members of this group, just reach the southern extremity of Ohio and do not come within 75 miles of Sugar Grove. The typical members of this group extend straight across the country at about the latitude of Philadelphia, but there is a strong tendency in many Carolinian plants like *Andropogon virginicus* (FIG. 8) to extend up the coastal

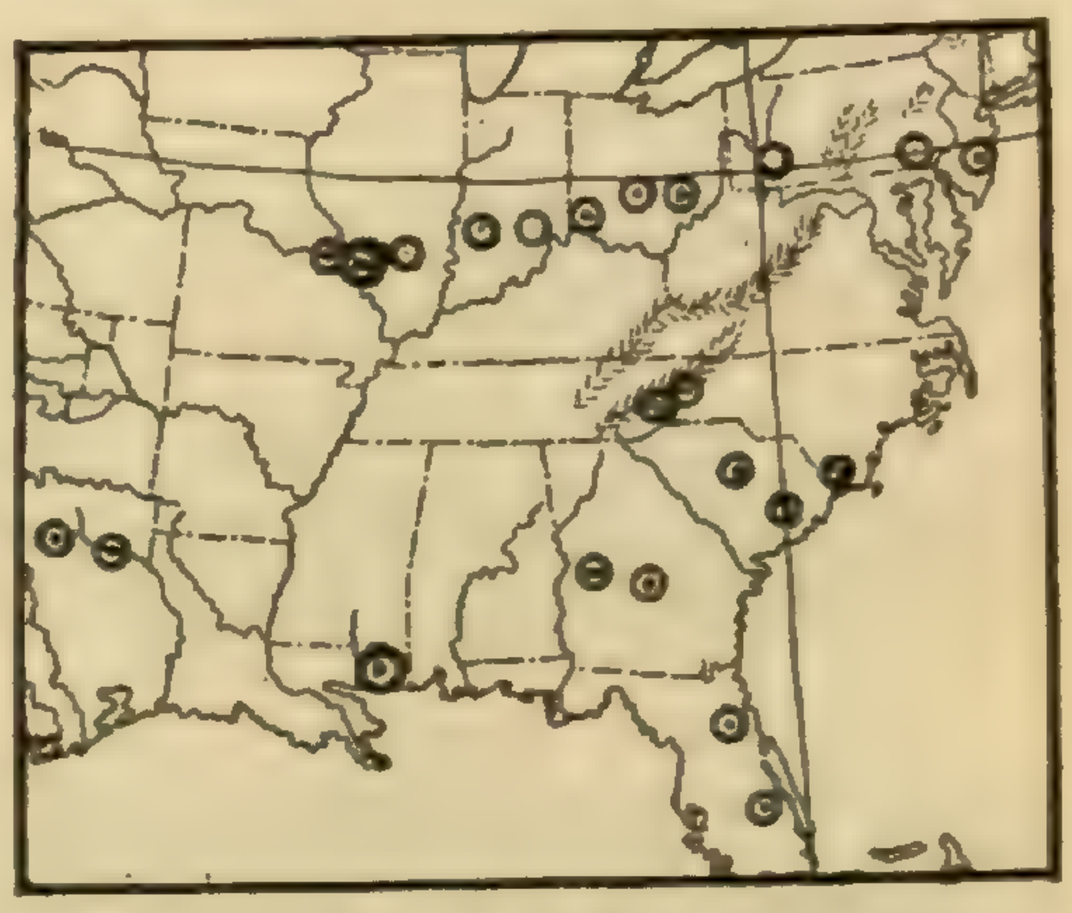

FIG. 7. Range of *Passiflora lutea*.

plain through New Jersey to Long Island or even to Massachusetts. These are starred (*) on the list. The coastwise distribution † of such plants finds its most striking exemplification in the occurrence

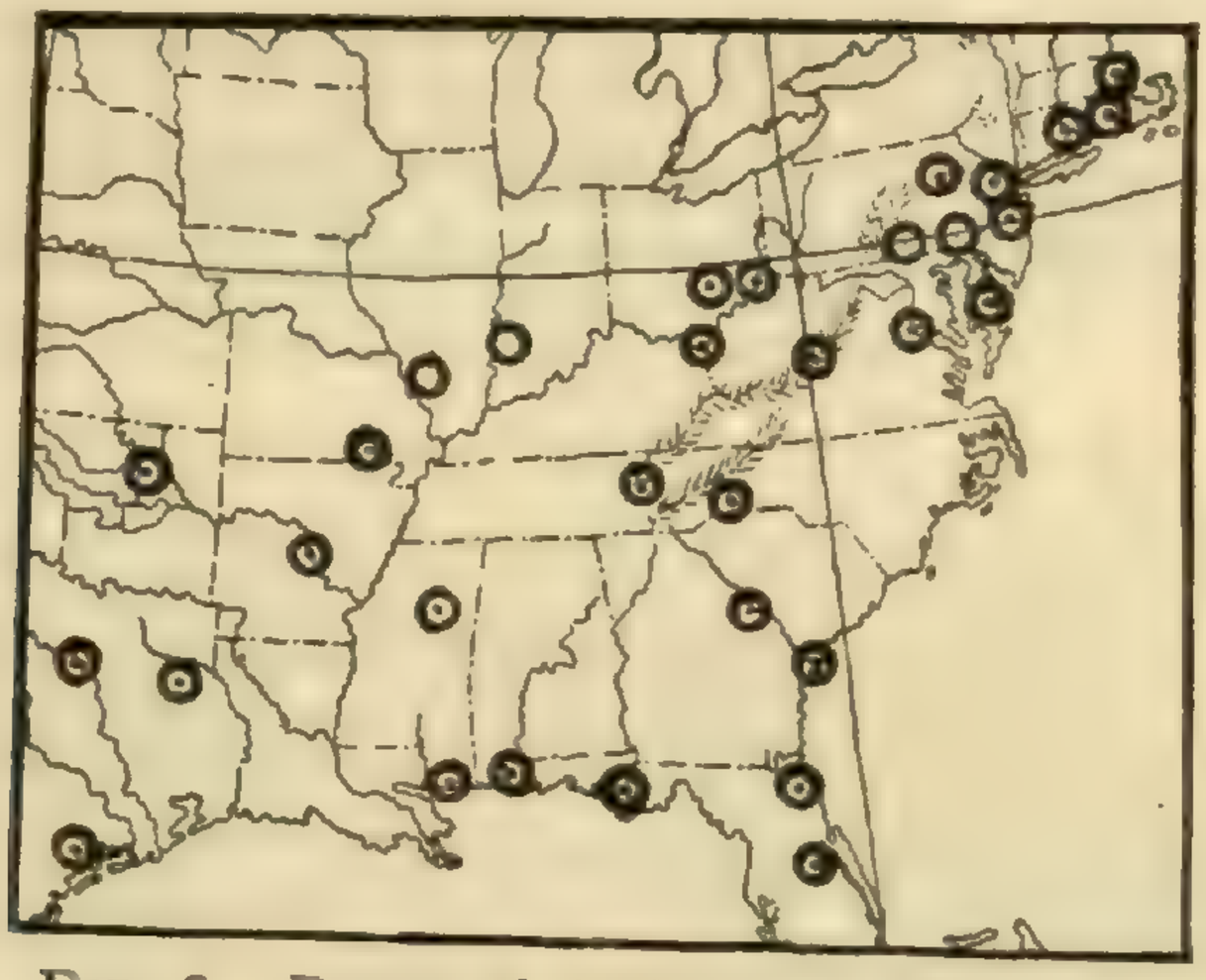

FIG. 8. Range of *Andropogon virginicus*.

of such a plant as *Schizaea pusilla* in Newfoundland.‡ The Carolinian plants which terminate at Sugar Grove number 32 and include:

*Andropogon virginicus
Aralia spinosa
**Aristida dichotoma*
**Asclepias variegata*
**Ascyrum multicaule*
**Betula nigra*§
Blephariglottis paramoena
Carduus virginicus
**Cassia nictitans*
Chrysopsis Mariana
Cunila origanoides
Dentaria heterophylla
Diospyros virginiana
Eupatorium aromaticum
Eupatorium coelestinum
**Eupatorium rotundifolium*
Hydrangea arborescens
Iris cristata
Koellia incana§
**Lechea racemulosa*
Lobelia leptostachys§
Lobelia puberula
Napaea dioica§
Panicum polyanthes
Panicum stipitatum§
Passiflora lutea
Porteranthus stipulatus§
Quercus minor
**Solidago erecta*
Stylosanthes biflora
Trichostema dichotomum§
Trifolium reflexum§

* Extending up the coastal plain into Long Island or New England.

† This interesting phenomenon has been described and its bearing discussed by Hollick, Plant Distribution as a Factor in the Interpretation of Geological Phenomena with especial reference to Long Island and vicinity. Trans. N. Y. Acad. Sci. 12: 189–202. 1893.

‡ See Fernald, l. c.

§ Not typical Carolinian plants. Of those marked thus, *Koellia incana*, *Panicum*

E. MISSISSIPPIAN PLANTS ON THE EASTERN EDGES OF THEIR RANGES.
Type range, ISOPYRUM BITERNATUM (FIG. 9).

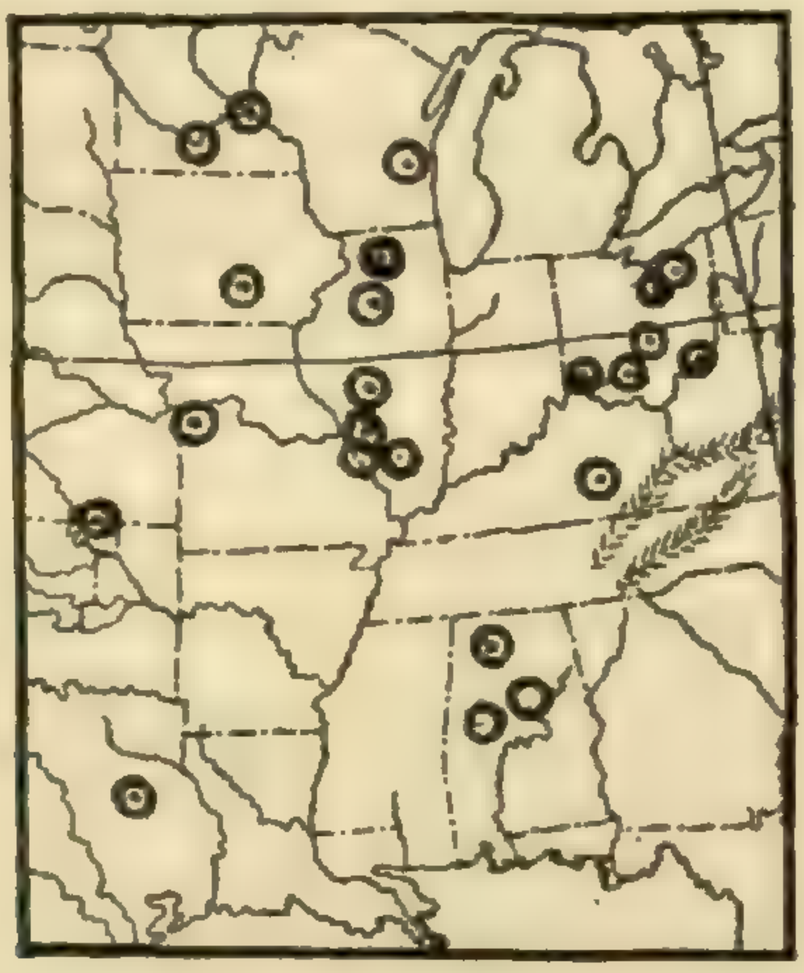

FIG. 9. Range of *Isopyrum biternatum*.

These are mostly plants characteristic of the great forest which once covered the Mississippi Valley and number 15 including:

*Aesculus octandra**
Afzelia macrophylla
Asclepias Sullivantii
Bidens aristosa
*Brauneria purpurea**
*Dodecatheon Meadia**
Fraxinus quadrangulata
Hypericum Drummondii
Isopyrum biternatum
Psoralea Onobrychis
*Quamasia hyacinthina**
*Smilax ecirrhata**
Sullivantia Sullivantii
*Valeriana pauciflora**
Veratrum Woodii

F. PLANTS ON THE SOUTHERN EDGES OF THEIR RANGES.
Type range, SCUTELLARIA GALERICULATA (FIG. 10).

This appears to be a miscellaneous aggregation without much similarity in range except that they are northern but not mountain plants. Probably further study and comparison would discover common characteristics as conspicuous as in other groups. Some of them like *Anemone canadensis* are bounded by the Basin

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stipitatum, and *Trichostema dichotomum* have boundaries running from northeast to southwest instead of east and west while *Napaea dioica* reverses the case and is reported northwestward as far as Minnesota. *Porteranthus stipulatus* and *Trifolium reflexum* are transitional between this and the next group in that they do not cross the mountains but stop in western New York. *Lobelia leptostachys* also is not known much beyond the mountains and is likewise transitional to the next group.

* Also known locally further east but the main body of the range stops in Central Ohio.

of the Great Lakes. Others like *Salix amygdaloides* have a wide distribution westward but taper eastward in a triangular area with its vertex in western New York, thus conforming to Harsh-

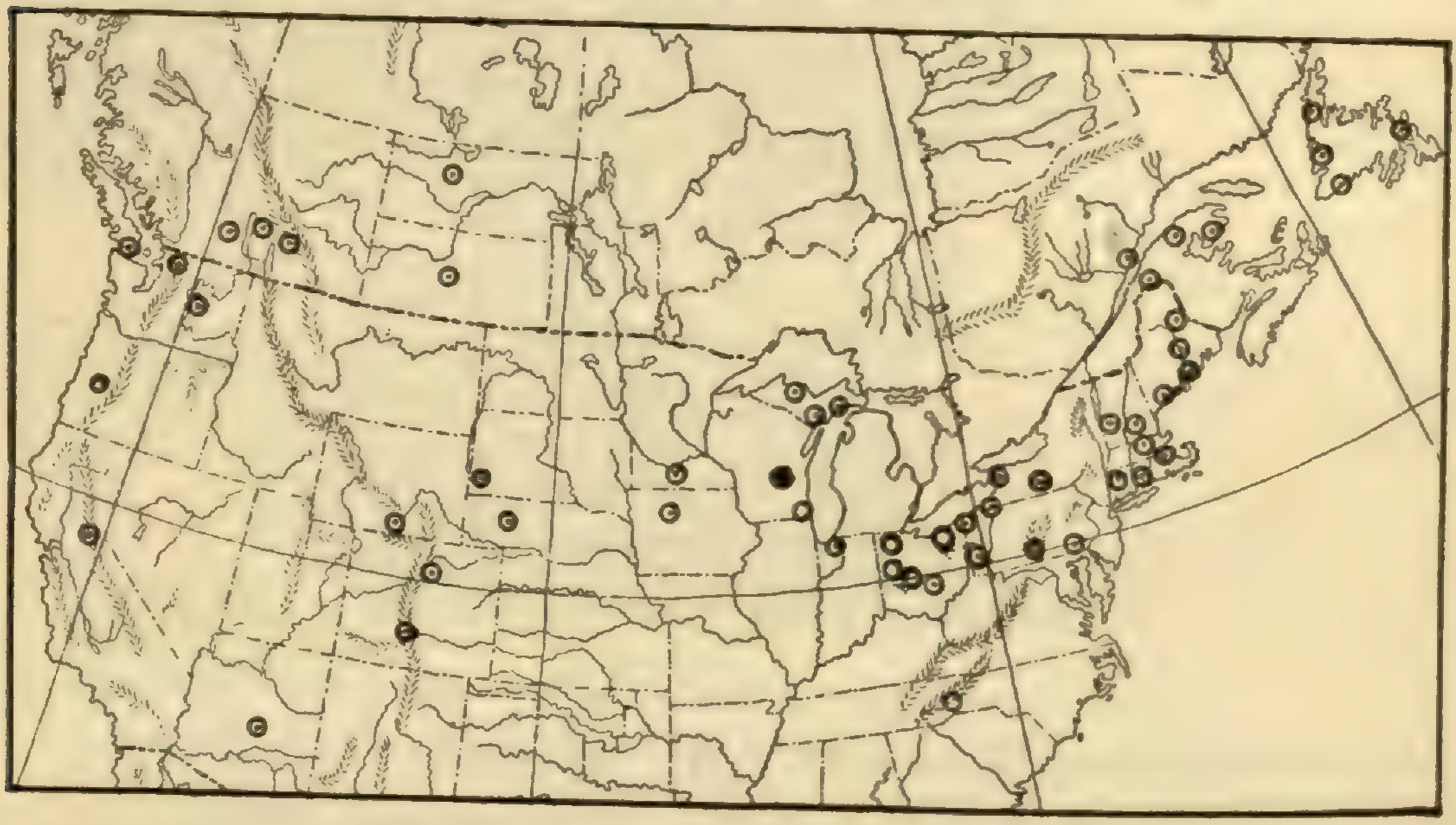

FIG. 10. Range of *Scutellaria galericulata.*

berger's* map of the Ohio-Tennessee area. 9 plants have been classed here as follows:

Anemone canadensis
Cornus stolonifera
Dasyphora fruticosa
Pedicularis lanceolata
Populus tremuloides
Salix amygdaloides
Saxifraga pennsylvanica
Scutellaria galericulata
Solidago juncea.

In addition to those given above there is one anomalous case which fits into no natural geographical range which I can discover. *Viburnum dentatum* comes down to our area from the northeast and meets *Viburnum molle* which comes up from the southwest. The characters which separate these species moreover do not hold in this region. It is evident therefore either that we do not understand these species and have only one of them even though there is a distinct variation from one part of the state to the other, or that they are not good species.

The presence at one place of so many species on the edges of

* Harshberger, J. W. Phytogeographic Survey of North America. Veg. der Erde 13: facing 790. 1911.

their ranges affords a favorable opportunity to study also their behavior. Are they rare or abundant? Does their reproductive apparatus function normally? Do those plants on their northern edges behave differently from those on their southern? The eastern from the western? Is it possible to assign any reasons for the location of their termini here rather than fifty or a hundred miles beyond? These questions will be considered in a following paper.

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The culture of cereal rusts in the greenhouse

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The desirability of maintaining cultures of parasitic fungi on the living host in the greenhouse for purposes of study and physiological experimentation is obvious, particularly so with those obligate forms that cannot be cultivated on artificial media. Methods of culture of the powdery mildews of the grasses and other members of the Erysiphaceae, and of a species of *Cystopus*, etc., Peronosporaceae, have been placed on an exact basis by the work of Reed (**28**, **29**) and Melhus (**23**). No exact data of this nature, however, are available for the rusts. Although a vast number of infection experiments on this group have been made in recent years, these have dealt only incidentally with conditions governing spore germination, infection, and spore formation, and in many cases our knowledge on these points is based on field experiments conducted under conditions not subject to rigid control. There are a great many scattered details in the literature as to conditions affecting the development of the rusts. I shall summarize only those that bear more especially on the problems of growing rusts in the greenhouse.

Smith (**33**) found that dew is of more importance in determining the prevalence of asparagus rust than rainfall. When little dew is formed infection cannot occur and sporulation may be checked, or altered, with a substitution of the teleuto for the uredo stage. This may occur in midsummer on the vigorously growing host as the result of excessive atmospheric dryness. He states, moreover, that abundance of soil moisture, instead of favoring rust development, acts as a check by giving the host greater vitality. This is in agreement with earlier observations by Stone and Smith (**34**, **35**). They found asparagus beds on light, dry soil heavily rusted while those on heavy, moist soil were comparatively free from rust. Sirrine's (**32**) observations also support the conclusion that dew is the most important agent in the spread of asparagus rust.

Morgenthaler (25) finds that mechanical injury of the leaves of the host favors teleuto as compared with uredo formation in the case of *Uromyces Veratri*. Tischler (36) found that shoots of *Euphorbia Cyparissias* infected with *Uromyces Pisi* became free from the rust mycelium when grown in a warm (25–27° C.) greenhouse.

Many factors doubtless influence the germination of rust spores. They frequently germinate in a few hours after being placed in water, as noted by de Bary. Often, however, though collected fresh, they fail to germinate for no apparent reason. This "capricious" germination has been noted by a large number of careful observers, and Eriksson, because of this uncertainty, does not consider the aecidiospores of the rusts of the cereals important factors in their dissemination. Schaffnit (31) explains this "capricious" germination on the ground that unless the spores are mature internally before detachment from their stalks they are incapable of germination. Complete maturity is attained only at a sufficiently high temperature (20°–25°) in an atmosphere calm enough to prevent their premature detachment. These conditions are not always realized in nature, hence the lack of uniformity in the results of germination tests.

Freeman (13) and Klebahn (19) both have found that spores which germinate poorly in water may produce an abundant infection on the host, and therefore argue that germination tests are not conclusive unless conducted on the host. Klebahn states that aecidiospores of *Peridermium Strobi* germinated slightly or not at all in water, very vigorously on the *Ribes* host and less vigorously, but abundantly, on a decoction of *Ribes*. Sappin-Trouffy (30) likewise noted a marked difference in the germination of aecidiospores of *Coleosporium Senecionis* in water and in a decoction of *Senecio vulgaris*. Schaffnit (31) on the other hand, obtained no increase in host decoctions over the germination in water nor any effect attributable to a mechanical excitation by the substratum. Marshall Ward (37), was unable to find any effect of raw or cooked extracts of various bromes on the germination of the uredospores of *Puccinia dispersa*.

The effect of various chemicals on rust spore germination has been investigated by Wüthrich (40) and Carleton (6). Wüthrich

(see TABLE I) has determined the inhibiting action of different concentrations of various acids and salts on the germination of aecidio- and uredospores of *P. graminis*. Carleton finds that compounds containing Hg, Cu, Fe, Pb, Cr, and strong acids inhibit the germination of uredospores of *Puccinia rubigo-vera*, *P. graminis* and *P. coronata* and that those which contain O, Na, K, Mg, S, C, and NH_3 in large proportions are favorable to germination.

The effect of temperature on spore germination has also received attention. Eriksson (9) found that aecidiospores of *Aecidium Berberidis*, *A. Rhamni*, and *Peridermium Strobi* and uredospores of *Puccinia glumarum*, *P. graminis* and *P. coronata* often germinated more readily at a few degrees below zero C. and on melting ice than at higher temperatures. Uredospores of *P. dispersa* according to Marshall Ward (37) germinate after freezing in ice for ten minutes. He attributes any increase in vigor obtained in this way to the drying action of the freezing and not to the low temperature. They germinated also at 27° but failed to do so at 30° and were killed at 65° to 70°. The optimum is near 20°. They germinate readily, if the spores are properly ripened and fresh and the temperature does not rise above 25°, in light, darkness, or red light, but less readily in blue light. Gibson (14) reports tests with uredospores of *Puccinia Chrysanthemi* as follows: Fifty per cent germination at 6°–6.5°, free germination between 7° and 21°, all at 21°–25°, one eighth at 24°–25°, and none at 30°. If kept dry at 35° for eighteen hours and then removed to 17° they germinate freely. Johnson (18) has determined the minimum, optimum, and maximum temperatures for germination of uredospores of the cereal rusts. These are: for *Puccinia graminis* on wheat, oats, and barley, 2° to 31°; for *P. rubigo-vera* on rye, 2°–30°; and for *P. coronata* on oats, 7°–8° to 30°. The optimum was determined by the general vigor of the germination tube and for all forms studied lies between 12° and 17°. This is somewhat lower than for *P. dispersa* as determined by Marshall Ward. Johnson suggests that these low cardinal temperatures may explain the difficulty of obtaining infections in very warm greenhouses and on hot summer days and may account for the observation that rust epidemics are favored by subnormal temperatures at critical infection periods.

The length of time during which uredospores of *P. graminis* retain their vitality was found by de Bary (3) to vary between one and two months, while the aecidiospores of the same form lost their color and capacity for germination in one month. Marshall Ward (38) obtained germination with uredospores of *P. dispersa* after having kept them in a dry state for 61 days. Miss Gibson (14) reports a germination of 25 per cent. with uredospores of *P. Chrysanthemi* after storage of 71 days but none a week later. One aecidiospore of a sowing of *Phragmidium Rosae-alpinae* germinated after storage of 82 days. Barclay (2) found uredospores of some forms capable of germination during periods of from two to eight months (see TABLE I) in the Himalayas. Bolley (5) obtained a 5 per cent germination with uredospores of *P. graminis* after exposure to air and sunlight during the month of August.

Many observers have shown that various rusts are able to winter over in the uredo stage in some regions, but these data do not involve the determination of the actual time during which the spores are viable.

Gibson (14) has shown that a large number of uredospores will germinate on the leaves of the wrong host and that their germ tubes will enter the stomata without, however, producing an infection. In these cases the end of the germ tube dries up in the substomatal chamber without further development. Because inoculation does not always result in infection, Marshall Ward (37) would distinguish sharply between these terms which are often used interchangeably. The passage of the germ tube into the host should be spoken of as inoculation and the subsequent development in the tissue of the host as infection. Pole Evans (11) has investigated the entrance of the germ tubes of uredospores of *P. graminis*, *P. glumarum*, *P. simplex*, and *P. coronifera* into the stomata of their respective hosts and the establishment of the mycelium in the tissue of the host. The uredospores germinate within twenty-four hours and the infection is well established by the third day. When the germ tube reaches a stoma it forms a swelling or appressorium directly over it. A branch from the appressorium next enters the stomatal slit and forms a large vesicle in the substomatal chamber into which the contents of the appres-

sorium and germ tube are poured. One or more infecting hyphae are now sent off from the substomatal vesicle and these immediately establish connections with the surrounding host cells by means of haustoria. The early stages of development and the position and shape of the substomatal vesicle, and the number of infecting hyphae arising from it, are morphological distinctions between the different species.

In the rusts the period between inoculation and sporulation is known as the incubation period. This apparently varies somewhat with different species but the normal range for the uredo as reported by a number of authors lies between eight and twelve days. Marshall Ward has noted that the normal incubation period is shortened during clear sunny weather and Iwanoff (**16**) found that shading delayed aecidium-formation in *P. graminis*.

What stimulus, or stimuli, determine the entrance of the germ tube into the stomata of the leaf has not been established. It is perhaps most generally held that the host exerts a chemical influence on the germ tube. If this is true it is apparently not a specific influence, since germ tubes have been shown to enter the stomata of quite the wrong host. Massee (**22**) endeavored to demonstrate a positive chemotropism but was unable to eliminate the effects of hydrotropism from the experiment. Marshall Ward (**37**) has noted an apparent heliotropic curvature in the germ tubes of *P. dispersa*. Balls (**1**) placed uredospores on a rubber film provided with small holes. Laboratory air was on one side of the film while the air on the other side was saturated with moisture at 23°. The germ tubes entered the holes and grew through into the region of higher pressure of water vapor. He believes that growth towards greater moisture will explain the entrance of the germ tube into the host.

A recent article by Melhus (**24**) on the culture of parasitic fungi deals with the culture of *P. Helianthi*, *P. coronata*, *P. graminis* and *P. Sorghi*. The methods employed by him consist in spraying the plants to be inoculated with a spore suspension, covering with a hood and placing in a refrigerator or humidity-box for twenty-four hours, at 14° for *P. Helianthi*, 16° for *P. coronata*, and 18° for *P. Sorghi*. He finds that *P. coronata* will not maintain itself even though supplied with plenty of host material. It is more

difficult to hold in culture than the sunflower rust, a fact which is attributed to the slower growth of the oat plants. Reinoculation is necessary about every three or four weeks. *P. Sorghi* is more easily cultured than the cereal rusts and Melhus has propagated it both winter and summer. The amount of infection increases as the corn plants grow larger and the fungus spreads from one culture to another by natural agencies.

I have tabulated the principal recorded observations on the influence of various conditions on spore germination and development in the rusts in TABLE I. These scattering and somewhat fragmentary records illustrate the incompleteness of our knowledge of rust physiology.

CULTURE METHODS

Preliminary experiments were made to determine how long single infections would maintain themselves under greenhouse conditions and whether they would self-propagate to any extent. The rusts used were *Puccinia dispersa* Erikss. on rye and *Puccinia coronifera* Kleb. on oats. The seedlings were grown in 5-inch pots and infections were secured by atomizing them with a uredospore suspension followed by covering with a bell jar for twenty-four hours. The incubation periods for both forms averaged about twelve days in this preliminary work. The infections secured maintained themselves for about two weeks after the first ripening of the pustules. After this time the number of pustules visibly decreased through withering and dying off of infected leaves and eventually the cultures became entirely free from infection. Close association of non-infected with infected plants did not produce new infections. No marked difference in susceptibility between old and young plants was apparent but the younger were found more desirable for inoculation because their greater compactness facilitated uniform covering with the spray.

My further experiments were planned to meet various requirements. First a method to maintain cultures of as nearly as possible constant virulence, with the fewest necessary transfers, over extended periods of time, was tested out. Such a method is suited, for example, to test the possibility of maintaining the rust for long periods in the uredo stage and for the study of the effects of such conditions of growth on its virulence, incubation period,

TABLE I

Species of rust	Spore form	Author	Conditions influencing spore germination and development										Length of incubation period
			Temperature			Moisture	Chemicals*		Host extracts	Host	Storage	Variation in light	
			Min.	Opt.	Max.		Inhibiting						
Puccinia graminis.....	II	DeBary	.....			+ after 2–3 hours in water	%		.....	.....	1–2 months	.....	8 days
Puccinia graminis.....	I	DeBary	.....				1.	KNO_3	.....	.....	1 month	.....	.....
							0.5	Na_2CO_3					
							0.1	$C_2H_2O_4$					
							0.1	$C_2H_4O_2$					
Puccinia graminis.....	II	Wüthrich	20–21°			+ after 15 hours	0.1	H_2SO_4	.....	.....	.....	.....	.....
							0.1	HCl					
Puccinia graminis.....	I	Iwanoff	.....			.....	0.1	$FeSO_4$	.....	.....	.....	Shading lengthens incubation period	.....
							0.01	$ZnSO_4$					
							0.01	$ZnCl_2$					
							0.01	$CuSO_4$					
							0.001	$HgCl_2$					
Puccinia graminis.....	II	Pole Evans	.....			Dry weather favors development							
Puccinia graminis.....	II	Eriksson	Low temperatures accelerate			"Capricious"	.....		.....	.....	.....	.....	.....
Puc inia coronata.....	II	Eriksson	Low temperatures accelerate			"Capricious"			.....	.....	.....	.....	.....
Puccinia glumarum.....	II	Eriksson	Low temperatures accelerate			"Capricious"	0.01	H_2SO_4	.....	.....	.....	.....	.....
							0.01	$FeSO_4$					
							0.001	$ZnSO_4$					

* All data as to chemicals are Wüthrick's.

TABLE I—*Continued*

Species of rust	Spore form	Author	Conditions influencing spore germination and development											Length of incubation period
			Temperature			Moisture	Chemicals		Host extracts	Host	Storage	Variation in light		
			Min.	Opt.	Max.		Favoring	Inhibiting						
Puccinia graminis	I	Wüthrich	.....	.....	.....	.....	0.001 0.0001	$CuSO_4$ $HgCl_2$	.....	.....	.....	.....		.....
Puccinia graminis	II	Johnson	2°	12–17°	31°	.....	.....		.....	.....	.....	.....		.....
Puccinia coronata	II	Johnson	7–8°	12–17°	30°	.....	.....		.....	.....	.....	.....		.....
Puccinia rubigo-vera	II	Johnson	2°	12–17°	30°	.....	.....		.....	.....	.....	.....		.....
Puccinia rubigo-vera	II	Carleton	.....			.....	Na K	Hg Cu	.....	.....	.....	.....		.....
Puccinia graminis	II	Carleton	.....			.....	Mg S	Fe Pb	.....	.....	.....	.....		.....
Puccinia coronata	II	Carleton	.....			.....	Ca NH_3	Cr Alkaloids	.....	.....	.....	.....		.....
Puccinia coronata	II	Melhus	16°			.....	.....	.....	.....	.....	.....	.....		8–12 days
Puccinia Helianthi	II	Melhus	14°			.....	.....	.....	.....	.....	.....	.....		10 days
Puccinia Sorghi	II	Melhus	18°			.....	.....	.....	.....	.....	.....	.....		8 days
Puccinia rubigo-vera	II	Plowright	+ after exposure to − 5° in open			.....	.....	.....	.....	.....	.....	.....		.....
Puccinia rubigo-vera	II	Bolley	.....	.....	.....	.....	.....	.....	.....	.....	30 days in open	.....		.....
Puccinia dispersa	II	Marshall Ward	10–12°	20°	26–27°	.....	.....	CO_2	No influence	.....	61 days	+ in dark and in red or blue light		7–10 days
Puccinia dispersa	II	Freeman	.....	.....	.....	Often poor in water	.....	.....	.....	Good	.....	.....		.....
Puccinia Asparagi	I, II	Smith	.....	.....	.....	Dew essential for infection	.....	.....	.....	.....	.....	.....		.....

TABLE I—*Continued*

Species of rust	Spore form	Author	Conditions influencing spore germination and development										Length of incubation period
			Temperature			Moisture	Chemicals		Host extracts	Host	Storage	Variation in light	
			Min.	Opt.	Max.		Favoring	Inhibiting					
Phragmidium Rosae-alpinae	I	Gibson	.....	.....	.....	.....	.....	.....	.....	Germ tubes enter wrong host	82 days	.....	.....
Puccinia Chrysanthemi....	II	Gibson	6–6.5°	21–25°	25–30°	.....	.....	.....	.....	.....	71 days	.....	.....
Puccinia Chrysanthemi....	II	Jacky	+ after exposure to − 25° in open			.....	.....	.....	.....	.....	.....	.....	.....
Phragmidium obtusum....	II	Dietel	+ after breaking out of ice and snow			.....	.....	.....	.....	.....	.....	.....	.....
Peridermium Strobi.....	I	Klebahn	.....			Weak in water	.....	.....	Fair	Abundant	5 weeks	.....	.....
Peridermium Soraueri....	I	Klebahn	.....			.....	.....	.....	.....	.....	20 days	.....	.....
Coleosporium Senecionis...	I	Sappin-Trouffy	.....			Poor or none in water	.....	.....	A-bundant	.....	.....	.....	.....
Uromyces Pisi.....	I	Tischler	Host outgrows rust in moist air at 25–27°			.....	.....	.....	.....	.....	.....	.....	.....
Uredo Bupleuri.....	II	Barclay	.....			.....	.....	.....	.....	.....	8 mo. 12 d.	.....	.....
Uredo Gomphrenatis.....	II	Barclay	.....			.....	.....	.....	.....	.....	7 mo. 7 d.	.....	.....
Puccinia Prenanthis.....	.....	Barclay	.....			.....	.....	.....	.....	.....	7 mo. 6 d.	.....	.....
Puccinia Caricis-filicinae.....	.....	Barclay	.....			.....	.....	.....	.....	.....	5 mo. 12 d.	.....	.....
Uromyces Vossiae.....	II	Barclay	.....			.....	.....	.....	.....	.....	5 mo.	.....	.....
Puccinia Acetosae.....	.....	Barclay	.....			.....	.....	.....	.....	.....	3 mo. 17 d.	.....	.....
Uromyces Pisi.....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 15 d.	.....	.....
Melampsora Lini.....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 15 d.	.....	.....
Puccinia flosculosorum....	.....	Barclay	.....			.....	.....	.....	.....	.....	2 mo. 7 d.	.....	.....

etc. It was found that it was necessary to transfer the infection to new cultures once a month. Five ripe, oval pustules were selected for each inoculation. The spores from these were removed with a scalpel and immersed in 25 c.c. of water in the bottle of the atomizer. This was then shaken vigorously to secure uniform distribution of the spores before application and the culture was subsequently covered with a bell jar for twenty-four hours. "Spring" rye and "Kherson" oats were used exclusively. About twenty-five seeds were sown to a 5-inch pot.

Six transfers at intervals of a month were made. At first seed for the next culture were sown two weeks prior to the date set for transfer, but a further simplification of method was secured by sowing a month prior to inoculation. Thus sowing and transfer could be made at the same time. Plants were a month old when inoculated and two months old when abandoned.

Well-infected cultures on both oats and rye were maintained for six months in this way. No attempts were made to measure exactly the degree of infection secured but the pustules were seemingly as numerous at the end of the period as at the beginning. Germination tests of spores in drop cultures made at various times gave 50–75 per cent. germination in six to twelve hours. The incubation periods during the six months were quite uniform. Twelve days was the longest incubation period recorded and ten days the shortest.

Cultures made in this way show relatively few sori. The method provides for maintenance of a rust culture but it does not provide an abundant supply of infected plants at all times. During the incubation period the pustules have disappeared from the old cultures and have not matured on the new ones. To have abundantly infected plants continuously available the following method was used. Transfers were made once a week instead of once a month. Since two weeks were required for complete ripening of the pustules it was necessary to run alternate series of host cultures. One series was ready for transfer one week and the other series the week following. Seeds for subsequent cultures of each series were sown at the time of inoculation and the seedlings were thus two weeks old when the rust was transferred to them. Cultures of *P. coronifera* have been maintained for eight months

by this method and the fungus has gone through thirty-seven generations of the uredo stage with no decrease in virulence.

It was soon found that even more simple methods of inoculation are equally if not more efficacious than the application of spore suspensions with an atomizer. The plants to be inoculated are first thoroughly atomized with water. A well-infected culture pot bearing fully ripe pustules is then held in a horizontal position immediately above them and given a vigorous shaking. The spores that fall from above are caught in the small drops of water provided by the spray. If the culture used is heavily infected the falling spores may be seen as yellow clouds. The inoculated plants are then covered for twenty-four hours. Four pots of seedlings can be inoculated simultaneously from the same culture and a uniform degree of infection secured on all four by placing them close together and holding the culture somewhat higher than for inoculating a single pot. It was found that spraying prior to inoculation could be dispensed with but the pustules secured were somewhat less numerous than when the spray was applied. To secure the best results the culture used for transfer must be heavily infected and the transfer made shortly after the ripening of the pustules. If transfer is delayed more than a week after sporulation begins, inoculation with a spore suspension must be resorted to.

Very numerous and uniformly distributed pustules were secured and maintained by this dry-spore method of inoculation. The approximate number of pustules per plant in a culture was determined in the following way.

For facility in counting the surface area of the pot it was divided into smaller areas with strips of cardboard. The number of plants and infected parts on each of the smaller areas was then easily ascertained. Ten plants were then taken at random from the culture, removed to the stage of a binocular, and the number of pustules on the infected parts determined. TABLE II shows the amount of infection on a typical culture. In this culture all of the first leaves were infected, 62.5 per cent of the second leaves, and 29.1 per cent of the sheaths. The average number of pustules on the first leaves of the ten selected plants was 574.4, on the second leaves, 22.9, and on the sheaths, 1.4. The small number of

pustules on the second leaves was due to the fact that only their tips were exposed at the time of inoculation. The number of pustules on the upper and lower surfaces of a leaf is sometimes equal and two pustules are often situated directly opposite each other. The average number of pustules per plant maintained in the mass culture experiments was about 200–300. The lowest average recorded for a culture was 161.6, the largest 598.7. The largest number of pustules counted on a single plant was 996 (plant 3, TABLE II).

TABLE II.

ANALYSIS OF INFECTION ON CULTURE 7C

Treatment: Innoculated by dry spore method, covered with bell jar. Number of plants, 72. Date planted, January 1. Date innoculated, January 13. Date of sporulation, January 24.

Number of parts	Part of plants	No. of parts infected	Per cent. infected
72	First leaves	72	100
72	Second leaves	45	62.5
72	Leaf sheaths	21	29.1

NUMBER OF PUSTULES ON TEN PLANTS SELECTED AT RANDOM

No. of plant	First leaves		Second leaves		Leaf sheaths	Total, entire plants
	Lower surface	Upper surface	Lower surface	Upper surface		
1	297	246	27	30	1	601
2	215	341	12	21	5	594
3	506	441	18	31	0	996
4	444	521	7	11	3	986
5	234	336	4	5	0	579
6	225	249	0	0	0	474
7	376	403	10	13	3	805
8	99	140	0	0	2	241
9	53	115	1	3	0	172
10	189	314	14	22	0	539
Total....	2638	3106	93	136	14	5987
Ave.....	263.8	310.6	9.3	13.6	1.4	598.7
Ave.....	574.4		22.9		1.4	598.7

NORMAL DEVELOPMENT OF THE UREDOSORI OF P. CORONIFERA

The period of incubation for the rust in the open greenhouse varied between eight and eleven days from October to December. Twelve days was the constant incubation period during December but this decreased to nine days in the latter part of January and

remained at nine days throughout February and March. The sequence of stages during a nine days incubation period may be divided into two periods. First, a period of vegetative development during which no evidence of infection is seen. Second, a fruiting period during which the stages in the formation of the pustules are apparent. The first period occupies five days after inoculation and the first visible evidences of pustule formation become apparent on the sixth day. The leaves on this day have a faint mottled appearance which is due to the presence of small areas that are lighter in color than the surrounding leaf tissue. These areas are visible only by transmitted light. On the seventh day the light areas become more conspicuous and their boundaries more sharply defined. The areas become slightly swollen on the eighth day and a light orange color is apparent. During the next twenty-four hours the development of the pustules is rapid. They continue to swell until the epidermis of the leaf is ruptured by a longitudinal slit and the orange mass of spores is extruded. The mass of spores hangs together for a time but breaks apart on drying and falls from the leaf as separate spores or in small groups when the leaf is disturbed.

OBSERVATIONS ON CONDITIONS AFFECTING SPORE GERMINATION, INFECTION, AND RATE OF DEVELOPMENT

Effect of moisture

It has been demonstrated a number of times during this culture work that a humid atmosphere provided by covering with a bell jar is necessary to secure infection. Abundant moisture may be supplied at the time of inoculation and still the plants will not become infected, in the greenhouse, unless they are covered soon afterwards. The drops of water apparently dry up before germination and infection result. The per cent of saturation in the greenhouse in which my experiments were made as obtained from the hygrometer records, averages about 75–80 per cent with a temperature range between 55 per cent. and 85 per cent. Although the conidia of *Erysiphe graminis* infect the cereals spontaneously under these conditions, the uredospores of *P. coronifera* will not do so.

To test the possibility of providing conditions of humidity

under which the rust might become self-propagating by close association of cultures, a sash frame culture box, 3 ft. square, was made of five window sash. The humidity maintained here when cultures were growing in it was quite constant and averaged 93 per cent. with occasional fluctuations of 2–3 per cent. Even in such a humid atmosphere new infections occurred only sparingly, although cultures were sprayed and heavily inoculated. To obtain good infections it was necessary to cover the cultures with bell jars as in the open greenhouse.

A direct comparison of the effects of covering and not covering in the culture box was obtained by a statistical study. Two pots of seedlings, each seven days old, were inoculated simultaneously from the same culture, after which one was covered for twenty-four hours and the other was left uncovered in the culture box. During the remaining eight days of the incubation period they were exposed to equal conditions of humidity. The difference in the degree of infection obtained on the two cultures was marked. The average number of pustules per plant on the covered culture was 161.6 as compared with 10.4 on the non-covered. This would be but a 6 per cent infection on the non-covered culture if that obtained on the covered is regarded as the normal. The difference in the degree of humidity to which the cultures were exposed for twenty-four hours after inoculation could not have been more than 7 per cent, as the average in the culture box was 93 per cent and the atmosphere under the bell jar was presumably saturated. It is rather striking that this difference of 7 per cent should have produced a difference in degree of infection of 94 per cent. The spores that produced the 6 per cent normal infection on the non-covered culture probably germinated more rapidly or were more favorably located with reference to moisture than the bulk of the spores.

Effect of temperature

To test the effect of different temperatures on the degree and rate of development of *P. coronifera*, two cultures of the same age were inoculated simultaneously from the same stock culture. Immediately afterwards one was placed in the greenhouse "stove"

where the temperature ranges between 20° and 30°.* The temperature here was quite constant for each twenty-four hours throughout the experiment. It did not fall below 25° from 10 A.M. to 5 P.M. nor rise above 20° from midnight to 6 A.M. The other culture was placed in the greenhouse where the temperature fluctuation was between 14.5° and 21°. Here the temperature remained quite constant at 16° for the greater part of the twenty-four hours. It reached 21° for a short period at noon and 14.5° at midnight. Both cultures were covered after inoculation. The first visible signs of infection became apparent on the culture in the "stove" on the fourth day after inoculation and fully ripe pustules were produced on the seventh day. Evidences of infection did not become visible on the culture in the greenhouse until the seventh day after inoculation, which was the date of sporulation for the culture in the "stove," and ripe pustules were not formed until the twelfth day. The high temperature of the "stove," which was an average increase of about 7–8°, was apparently responsible for a marked increase in the rate of development of the fungus and a decrease of five days in the incubation period. No differences in the degree of infection secured on the two cultures were apparent. The experiment was repeated immediately, but without a control, and the incubation period for this culture in the "stove" was but six days. This is the shortest incubation period I have observed.

Further cultures gave results as follows. No. 7 in the "stove," incubation period seven days. The temperature for each day was 20° from 6 P.M. to 6 A.M. and 25–30° from 8 A.M. to 2 P.M. Three controls in the greenhouse, incubation period nine days. Temperature 10–15.5° from 6 P.M. to 6 A.M. and 15.5–21° from 9 A.M. to 5 P.M. No. 8 in the "stove," incubation period nine days. There were many minor fluctuations in this period. The maximum was 30°, the minimum 8°. The general range was distinctly lower than in the preceding test. Two controls in the greenhouse, incubation period twelve days. Temperature 10–15.5° from 6 P.M. to 6 A.M. and 15.5–21° from 10 A.M. to 3 P.M.

* The temperature records were obtained with Richard Frères' self-recording thermometers.

Effect of light

To determine the effect of light exclusion on spore germination and rate of development, four culture pots of the same age, seven days, were inoculated simultaneously. Immediately afterwards one of the four was transferred to a physiological dark room which joins the greenhouse. A continuous circulation of air between the two rooms is maintained by an electric fan. Thus the average degree of humidity of the dark room, which is about 80 per cent., does not fall below that of the greenhouse although the range of fluctuation, which is from 60 per cent. to 95 per cent., is somewhat greater. The other three cultures were placed in the culture box as controls. The culture was exposed in the dark room for three days and at the end of this time was returned to the culture box. The plants at this time were quite as green and fresh as those of the control cultures and could not be distinguished from them. The incubation period for the three controls was eight days, while that of the culture left three days in the dark room was eleven days. At the time of sporulation some of the leaves of this culture showed signs of yellowing at their tips. No pustules were produced on these discolored areas but on the normal green parts they were as numerous as on the controls. The difference of three days in the incubation periods is exactly equal to the period of light exclusion and indicates a complete arrest of the development of the fungus in the dark room.

The effect of light exclusion during the latter part of the incubation period was also tested. Four cultures were inoculated and placed in the culture box. Four days later one of them was transferred to the dark room, where it was left four days, and then returned to the culture box. No signs of infection were visible on it at this time, while the unripe pustules on the controls were plainly visible. The pustules on the controls ripened on the ninth day, while three additional days, twelve days in all, were necessary for a similar development of the culture that had been in the dark room. By excluding light four days in the latter part of the normal incubation period, the maturation of the rust had been delayed three days. This shows that even after the fungus has become well established in the host its development is strongly retarded in complete darkness.

The average difference in degree of humidity, of approximately 13 per cent, between the culture box and the dark room could not have been an important modifying factor in these results, as I have found that the incubation period is not modified by relative degrees of humidity after the first twenty-four hours. Thus parallel sets of cultures, when grown in the culture box and in the greenhouse under similar conditions of light and temperature but with the same difference in humidity that is found between the culture box and the dark room, had the same incubation period. Likewise when a culture was kept under a bell jar during the entire incubation period, with occasional removal for change of air, there was no difference between its incubation period and that of the control in the greenhouse that was covered for the first twenty-four hours only.

The question naturally arises how this retardation of the growth of the fungus is brought about. It may be the direct effect of total absence of light on the fungus itself. Then, again, it is possible that the fungus simply suffers from lack of food, since the host is incapable of assimilation in the darkness. It seems hardly possible, however, that such a complete inhibition in the growth of the fungus should have resulted in the brief time involved unless it is dependent on the transition products in photosynthesis. This latter possibility is by no means inconceivable and should this explanation prove the correct one it could be made the basis for an explanation of the obligate parasitism of the rusts and their inability to develop on any form of artificial medium.

VIABLE PERIOD OF UREDOSPORES

Two series of tests were made to determine the period through which the uredospores of *P. coronifera* would retain their vitality. Ripe spores were removed from pustules on the cultures and placed in small gelatine capsules which were then stored in the laboratory at room temperature. The first set of spores was stored on March 13. A drop culture made on this date gave a high per cent of germination in twelve hours. Drop cultures of the stored spores were made on March 19, 23, and 28 and April 12 and 30. From 9 to 16 per cent. of the spores sown germinated in each of these tests. No further trials were made until June 1 and at this time

the spores were colorless and failed to germinate. The last germination obtained was after 48 days of storage and the spores had lost their capacity for germination at some time between 48 and 80 days.

Another lot of spores were stored on November 26. These germinated in gradually decreasing per cents on January 8, 18, and February 2, 11, 18. The length of time required for the development of a germination tube increased from a period of 6–12 hours in November to a period of 36–48 hours in February. In the last drop culture made, on February 18, only 29 spores of 1,013 tested germinated. These few spores, about 0.2 per cent, had germinated after 84 days storage.

CONTROL OF MILDEW

The powdery mildew, *Erysiphe graminis*, became so abundant on the oats cultures that measures for its control became necessary. The mildew spreads rapidly in the greenhouse and outgrows the rust to such an extent that rust culture work may be seriously interfered with. Attempts at exclusion of the mildew by isolation of the cultures and inoculation with uredospores selected from apparently non-mildewed leaves proved unavailing.

The control and total exclusion of the mildew was achieved by treatment with sulphur dust. This was applied with a powder gun, twenty-four hours after rust inoculation. The plants were also atomized with a weak solution of sulphuric acid (1/1000) prior to the application of sulphur and were covered afterwards for twenty-four hours. With this treatment no mildew developed while control cultures became heavily infected.

This work was undertaken at the suggestion of Prof. R. A. Harper, to whom I am indebted for suggestions and criticisms.

SUMMARY

1. Two of the cereal rusts, *Puccinia dispersa* Erikss., on rye, and *P. coronifera* Kleb., on oats, have been cultured in the uredo stage, on the living hosts in the greenhouse, for a consecutive period of six months, from December 1912 to June 1913, by the transfer of infection once a month. *P. coronifera* was also cultured for a period of eight months, from September 1912 to May 1913,

with transfer of infection once a week. During this period the rust went through 37 generations of the uredo stage. No decrease in the degree of infection secured resulted from such continuous culture.

2. The average degree of infection maintained in mass cultures was approximately 200 pustules per plant. The largest number of pustules counted on an individual plant was 996.

3. *P. coronifera* does not self-propagate to any extent even when abundant host material is supplied and a constant humidity of 93 per cent is maintained.

4. High humidity is the essential factor in securing successful inoculation with uredospores of *P. coronifera*. No infections resulted when cultures were exposed in an atmosphere of 75 to 80 per cent of humidity, and at 93 per cent only 6 per cent of the normal degree of infection was obtained. Normal infections were secured only when cultures were covered with a bell jar for twenty-four hours subsequent to the application of spores.

5. The rate of development of *P. coronifera* increased with temperature increase. A decrease in the normal incubation period of five days, or 41 per cent, was produced in the "stove" where the temperature ranged from 20° to 30° while the range at which the normal cultures were grown was 14.5° to 21°.

6. Total light exclusion either early or late in the incubation period checks the development of *P. coronifera* and results in an almost complete cessation of growth.

7. Uredospores of *P. coronifera* when stored at room temperature gradually lose their capacity for germination. A 0.2 per cent germination was obtained after storage of eighty-four days.

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(1910–1913)

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Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Vol. 40 No. 10

BULLETIN

OF THE

TORREY BOTANICAL CLUB

OCTOBER, 1913

Notes on Carex—VII

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CAREX UMBELLATA AND ITS ALLIES

A study of a number of recent collections, chiefly from the western part of the United States, has brought about the conclusion that in addition to *Carex umbellata* Schk. and *Carex deflexa* Hornem. and their allies, there are a considerable number of additional species belonging to the group Montanae, characterized by the development of pistillate spikes on subradical peduncles or on very short culms.

A natural division of these species can be made from certain characters taken from the perigynia. While all of the Montanae have the perigynia strongly 2-ribbed or 2-keeled, certain species of the group now under consideration found in California also have the outer face finely many-nerved. In all other members of the group the perigynia are nerveless or at most have on one face a few partly developed nerves on the lower half of the body.

Next to be separated are two closely related species of the southeastern United States (*Carex nigro-marginata* and *Carex floridana*). These are to be distinguished by the fact that while the spikes are on very short culms and may appear basal they are not on basal peduncles. Each culm really bears one to several pistillate spikes sessile at the base of the staminate spike; and elongated radical peduncles bearing only pistillate spikes are not normally developed, as in the remaining species.

After making this division probably the most satisfactory and

[The BULLETIN for September (40: 461–528) was issued 10 S 1913.]

natural method of telling *C. deflexa* and its allies from *C. umbellata* and its allies is that there are always pistillate spikes at the base of the staminate in the former, and the lowermost of these has a leaflet-like bract exceeding the inflorescence. This bract is rarely auriculate, and if colored at all at base is purplish-brown tinged. In the other group all the pistillate spikes are frequently subradical, but when there is a pistillate spike at the base of the staminate its bract is squamiform and shorter than the inflorescence, or else, if rarely longer, it is auriculate and strongly reddish-tinged at base.

Carex deflexa has a close ally in *C. Rossii*, the two species having been often confused. However, in *C. deflexa* itself the rootstock is very slender, horizontally creeping and short-stoloniferous; the perigynium is very small (about 2.5 mm. long) and strongly exceeds the scales; and the beak is short and but inconspicuously bidentate. In *C. Rossii*, as stated by Dr. Holm (Am. Journ. Sci. IV. **16**: 37. 1903), the rootstock is "much more robust, relatively shorter and ascending, not horizontal and not stoloniferous in the stricter sense of the word." This last species, too, has larger, longer-beaked and conspicuously bidentate perigynia, with relatively longer scales.

Carex brevipes W. Boott, a little-known species of the far western mountains, seems to be valid. It has the habit of growth of *C. Rossii*, but the short-beaked, narrow perigynia are about as small as those of genuine *C. deflexa*.

A very interesting collection made by Mr. W. W. Eggleston in the northern part of New Mexico in 1911, contains two new species belonging to the group of species now under discussion. One of these is related to *Carex deflexa* and its allies. It differs, however, in having few-flowered pistillate spikes even on fully developed plants. The beak of the perigynium is obliquely cut at apex and becomes slightly bidentate in age, and the margins are scarcely serrulate.

Another plant collected by him, now named *Carex geophila*, differs from the real *Carex umbellata* in having a globose perigynium body fully 1.75 mm. or more wide; the beak is not strongly 2-edged. The eastern species grouped with *Carex umbellata* have the perigynium body triangular-globose and but 1–1.5 mm. wide, while the beak is strongly 2-edged.

Another species most closely related to *Carex geophila* occurs

along the Pacific coast from San Francisco to Vancouver Island. It furnishes the basis for the reports of the occurrence of *Carex umbellata* on the Pacific coast, and specimens of it are probably also responsible for the large perigynia at times attributed to that species. This plant, which I am calling *Carex brevicaulis*, has pistillate spikes maturing 1–4 strongly pubescent perigynia and the culms are little fibrillose at base. *Carex geophila* on the other hand has pistillate spikes maturing some 5–15 puberulent perigynia and the culms are extremely fibrillose at base.

Several distinct species have been referred to *Carex umbellata* Schk. The genuine plant is distinguished by its deep green narrow erect leaves, the old reaching an extreme width of 2.5 mm., and the width of the young ones at fruiting time averaging about 1.5–1.75 mm. The cuspidate pistillate scales are normally lanceolate or narrowly ovate-lanceolate, and usually do not entirely conceal the lower part of the perigynia. The long-beaked perigynia are 3 mm. long or more and short-pubescent, and the beak is markedly bidentate.

In parts of the country, especially in the north and west, the place of *Carex umbellata* is often taken by a closely related species, the perigynia of which are smaller (3 mm. long or less) and have a short (0.5 mm. long) shallowly bidentate beak. The scales are ovate and vary from acutish to cuspidate, and in the basal spikes tend strongly to conceal the lower part of the perigynia. This plant is the var. *brevirostris* Boott; the *C. abdita* of Mr. Bicknell. My own experience is that this species occurs in limestone districts and that *Carex umbellata* is a species not found in such districts. A closely related species ranging from Missouri to Texas has also been separated.

Thoroughly distinct is the coastal plant described by Professor Fernald as var. *tonsa* (Proc. Am. Acad. **37**: 507. 1902), and by Mr. Bicknell raised to specific rank (Bull. Torrey Club **35**: 492. 1908). While the long glabrous perigynia make it well marked, the wide stiff spreading leaves referred to by Mr. Bicknell are even more characteristic, and in the field distinguish the plant at a distance from *Carex umbellata* when growing with it. *Carex tonsa* is an abundant species in parts of the pine barren country of New Jersey.

The main distinctions between those members of the Montanae which are here discussed and which differ from all the other members of the group in having the pistillate spikes or some of them on short culms or on basal peduncles and so hidden among the leaves, may be summarized as follows:

I: Perigynia finely many-nerved as well as strongly 2-keeled.
  Scales purplish-tinged, obtuse to cuspidate; perigynium body globose; staminate spikes many-flowered; basal pistillate spikes on elongated, very slender peduncles. 1. *C. globosa.*
  Scales reddish-brown tinged, cuspidate or long-awned; perigynium body oval; staminate spikes few-flowered; basal pistillate spikes on short erect peduncles. 2. *C. Brainerdii.*

II. Perigynia strongly 2-keeled, otherwise nerveless (except at times obscurely coarsely nerved at base).
  A. Pistillate and staminate spikes closely contiguous (the culms often very short).
    Achenes normally triangular; scales strongly dark-margined; stolons short, ascending; culms strongly fibrillose at base. 3. *C. nigro-marginata.*
    Achenes normally lenticular; scales at most moderately dark-margined; stolons long, horizontal; culms little fibrillose at base. 4. *C. floridana.*
  B. Lower pistillate spikes widely separate (on subradical peduncles).
    Bract of lowest non-basal pistillate spike leaflet-like, exceeding culm; if at all colored, purplish-brown tinged at base.
      Rootstock slender; culms normally loosely cespitose (perigynia 2.5 mm. long, short-beaked, shallowly bidentate; staminate spike 2.5 mm. long, inconspicuous); northeastern species. 5. *C. deflexa.*
      Rootstock stout; culms densely cespitose; western species.
        Upper pistillate spikes normally several- to many-flowered; perigynium beak bidentate, the margins ciliate-serrulate.
          Perigynia 2.5–3 mm. long, the beak 0.25–0.75 mm. long, shallowly bidentate. 6. *C. brevipes.*
          Perigynia 3–4.5 mm. long, the beak longer, bidentate. 7. *C. Rossii.*
        Upper pistillate spikes 1–3-flowered; perigynium beak obliquely cut, in age bidentulate; the margins little if at all ciliate-serrulate (New Mexico). 8. *C. pityophila.*
    Bract of lowest non-basal pistillate spike, if present, squamiform and shorter than culm; or, if longer, auriculate and strongly reddish-brown tinged at base.

Perigynium body globose, 1.75 mm. or more wide; beak not strongly 2-edged.
Pistillate spikes with 5–15 puberulent perigynia; culms extremely fibrillose at base (New Mexico). 9. *C. geophila.*
Pistillate spikes with 1–4 strongly pubescent perigynia; culms little fibrillose at base (Pacific slope). 10. *C. brevicaulis.*
Perigynium body triangular-globose, 1–1.5 mm. wide; beak strongly 2-edged.
Perigynia 2.5–4 mm. long, pubescent; leaf-blades slender, light green, ascending, 1.5–3 mm. wide.
Short-stoloniferous, the new shoots phyllopodic, the sheaths rarely filamentose (perigynium beak very short; achenes roughened). 11. *C. microrhyncha.*
Densely cespitose, the new shoots aphyllopodic, erect-ascending, the sheaths filamentose.
Perigynia 2.5–3 mm. long, the beak less than half length of body; achenes brownish, shining, minutely pitted, orbicular-obovoid. 12. *C. abdita.*
Perigynia 3.25–4.25 mm. long, the beak more than half length of body; achenes grayish black, dull, minutely roughened, oblong-obovoid. 13. *C. umbellata.*
Perigynia 3.5–4.5 mm. long, glabrous except long beak; leaf blades stiff, deep green, spreading, 2.5–4 mm. wide. 14. *C. tonsa.*

1. CAREX GLOBOSA Boott, Proc. Linn. Soc. 1: 259. 1845

Carex umbellata var. *globosa* (Boott) Kükenth. in Engler, Pflanzenreich 4^{20}: 453. 1909.

Clumps medium-sized, from elongated slender rootstocks, stoloniferous, the culms 15–35 cm. high, phyllopodic, slender, exceeding leaves, roughened on angles above, strongly fibrillose and more or less reddened at base. Leaves with well-developed blades five to eight to a fertile culm, the lowest clustered, the upper more or less widely separate, the blades flat with revolute margins, 1.5–2.5 mm. wide, varying in length from 3 cm. to 3 dm. (on sterile culms), attenuate-pointed, strongly roughened; terminal spike staminate, erect, short-peduncled, 1–2 cm. long, 2.5–4 mm. wide, many-flowered, the scales oblong-obovate, obtuse or acute, purplish brown with lighter center and hyaline margins; pistillate spikes two or three (with additional basal ones on long capillary

peduncles), approximate, erect, sessile or a little peduncled, 5–10 mm. long, 4–8 mm. wide, short-oblong or suborbicular, containing 4–10 ascending, rather closely arranged perigynia in few ranks; bracts leaflet-like, shorter than to a little exceeding inflorescence, little sheathing, occasionally with a purplish tinge at base; scales ovate, obtuse to cuspidate, purplish with lighter center and hyaline margins, somewhat wider and longer than perigynia; perigynia 5 mm. long, the body globose, 2.25 mm. wide, puberulent or short-pubescent, 3-angled, noticeably nerved, abruptly narrowed to a prominent stipitate base and abruptly beaked at apex, the beak 0.75–1.25 mm. long, strongly bidentate; achenes obtusely triangular, closely fitting within perigynia, short-obovoid, 2 mm. long; stigmas three.

All specimens seen referable to this species are from the coastal counties of California and the islands off the coast. The range so shown is from Santa Cruz Island and Santa Barbara north as far as Sonoma County. The specimens from the Yosemite Valley referred to this species seem more properly referable to the following species.

SPECIMENS EXAMINED:

CALIFORNIA: Oakland, *Bolander* (C., L. S.*); "California," *Bolander*, 1865 (L. S.); Oakland, *Bolander 20* (H.); Oakland, *Bolander 2295*, May, 1866 (H.); Island of Santa Cruz, *Brandegee*, Apr. 1888 (N. Y.); Monterey County, *Davy 7366* (P.); Sonoma County, *Congdon 84*, May 29, 1892 (P.); Mt. Tamalpais, Marin County, *Heller 5716*, June 18, 1902 (L. S., N. Y.); San Diego, *Brandegee*, 1889 (N. Y.); Sonoma County, *Congdon*, May 30, 1895 (L. S.); Santa Lucia Mts., Monterey County, *Davy 7724*, May, June, 1901 (H.); Santa Barbara, *Brewer 303* (H.; L. S.); *Brown 370*, June 1897 (N. Y.); Redwoods, Marin Co., *Bolander V+W*, 1866 (C.).

2. **Carex Brainerdii** sp. nov.

In large clumps from slender, elongated rootstocks, the culms from very short to 15 cm. high, phyllopodic, reddened and slightly

* Key to the abbreviations of the names of herbaria used in the present paper: H., Harvard University; L. S., Leland Stanford Junior University; N. Y., New York Botanical Garden; P., S. B. Parish; B., Ezra Brainerd; K. M., Kenneth K. Mackenzie; D. C., Geological Survey of Canada; N., U. S. National; C., Columbia University; Piper, C. V. Piper.

fibrillose at base, much exceeded by leaves, slender, very rough on the sharp angles; sterile shoots strongly aphyllopodic. Leaves with well-developed blades four to eight to a fertile culm, the blades flat with slightly revolute margins, 1.5–3 mm. wide, those of the fertile culms short, of the sterile up to 25 cm. long, much roughened on both sides and averaging wider than those of the fertile; terminal spike slender, staminate, 5–8 mm. long, about 0.5 mm. wide, sessile or short-peduncled, few-flowered, the scales lanceolate or ovate-lanceolate, acuminate with 1–3-nerved green center and broad hyaline margins richly chestnut-tinged; pistillate spikes 4–6, 1–4-flowered, the upper 2 or 3 approximate, sessile or short-peduncled, the others basal, widely separated and strongly peduncled (the erect peduncles not much elongated), the zigzag rachis often terminating in a sterile flower; bracts of upper spikes well-developed, green, hyaline-margined and chestnut-tinged, all or only the lowest exceeding inflorescence, the lower more or less strongly sheathing, the upper sheathless or nearly so; scales ovate or ovate-lanceolate, cuspidate or long-awned with several-nerved green center, and with wide, strongly hyaline reddish-brown tinged margins, usually slightly longer but narrower than perigynia; perigynia softly short-pubescent, green, usually reddish-brown tinged, 4.5 mm. long, the body oval, 2.5 mm. long, 1.75 mm. wide, strongly 2-ribbed, finely many-nerved on outer face, nearly orbicular in cross-section, strongly stipitate (1 mm.), abruptly contracted into the serrulate, hyaline-tipped, bidentate beak 1 mm. long; achenes triangular with strongly convex sides, closely enveloped by perigynia, 2.25 mm. long, nearly 1.75 mm. wide, truncate at apex, round-tapering at base; style slender, not enlarged at base, readily detached; stigmas three.

The type specimen (herb. Brainerd) of this distinct plant was collected by Dr. Ezra Brainerd (*121*) in El Dorado County, California, on July 19, 1897, on a mountain north of Slippery Ford in the Sierra Nevada Mountains. A duplicate of the type is in the Gray Herbarium. *Bolander 6196*, collected in 1866 in the Yosemite Valley (H.; L. S.), a specimen collected by Mrs. Austin, in 1877, in Plumer County (H.), and *H. E. Brown 370*, collected near Sisson, Siskiyou County, California (N. Y.) are probably to be referred to this species. None of these specimens, however, is in very good condition.

3. CAREX NIGRO-MARGINATA Schwein. Ann. Lyc. N. Y. 1: 68. 1824

Carex lucorum var. *nigro-marginata* Chapm. Fl. S. E. U. S. 539. 1860.

Densely cespitose, the stolon short, ascending; culms 2–10 cm. high, much exceeded by the leaves, triangular, rough on the angles, very strongly fibrillose at base, several together with a common cluster of leaves at the base. Leaves numerous and conspicuous, the blades from very short to 35 cm. long, 2–4 mm. wide, flat, very rough, the mid-nerve prominent; staminate spike sessile, 5–8 mm. long, 2–3 mm. wide, the ovate scales obtusish, brownish with greenish midrib and narrow hyaline margin; pistillate spikes two or three, sessile, erect, contiguous or the lower slightly separate, the upper at the base of the sessile staminate spike, orbicular or ovoid-orbicular, 4–7 mm. long, 3–5 mm. wide, closely flowered, with about 6–15 ascending perigynia; bract of lower spike well developed, green, attenuate, 1.5 mm. wide at base, 5–25 mm. long, and from shorter than to exceeding the inflorescence, the upper bracts similar but shorter; scales ovate, acutish to short-cuspidate, from slightly shorter to slightly longer than the perigynia, with a broad strip of green in the center and conspicuous brownish black margin, or at times in immature specimens the brownish black margin narrow and inconspicuous; perigynia 3.5 mm. long, the body oval, 1.75 mm. long, tapering into the stipitate base 0.75 mm. long, the beak 1 mm. long, the body compressed-orbicular and somewhat obscurely triangular in cross-section, 1 mm. wide, narrowly ridged along the sides, otherwise nerveless, it and the beak minutely puberulent, the beak bidentate; achenes short-triangular, 1.5 mm. long, closely fitted to the perigynia; stigmas three.

Differs from *Carex floridana* in (1) its normally triangular achenes, (2) strongly dark-margined scales, and (3) often stiff culms, which are (4) strongly fibrillose at base, and (5) in its short ascending stolons instead of long creeping ones, thus making the plant more densely cespitose.

Forms of *Carex varia* Muhl. in which the leaves much exceed the culms may key into this species or the following one. Their narrow slender leaf-blades, and the lack of dark margins to their scales distinguish such specimens from the present species, and the absence of the long stolons and the lenticular achenes of *Carex floridana* serve to distinguish that species.

SPECIMENS EXAMINED:

NEW YORK: Babylon, *Leggett*, May 21, 1869 (C).

NEW JERSEY: Landisville, Atlantic Co., *Gross*, 1872+1883 (N. Y.) and May 28, 1898 (K. M.); Tuckerton, *Mackenzie*,

May, 1911 (K. M.); South Lakewood, *Mackenzie 4536*, May 15, 1910 (K. M.); Milford, *Porter*, May 27, 1867+1868 (N. Y.); Lakewood, *Torrey Club*, May 28, 1898 (N. Y.); Holland Station, *Garber*, June, 1868 (C); "New Jersey," *Smith* (B).

PENNSYLVANIA: Monroe, Bucks County, *Ruth*, May, 1885 (N. Y.); French Creek, *Brinton*, May 22, 1892 (C).

DELAWARE: Centreville, *Commons*, May, 1864 (N. Y.).

DISTRICT OF COLUMBIA: *Steele*, April 29, 1899 (K. M.); *M. A. Curtis*, 1845 (C).

NORTH CAROLINA: *M. A. Curtis* (N. Y.); Chapel Hill, *Ashe 3006* (N. Y.), April, 1897 (B); Salem, *Schweinitz* (C); "North Carolina," *Chapman* (C); *Hunter* (C); Tryon, *Brainerd*, April 14, 1909 (B).

SOUTH CAROLINA: Greenville, *Mackenzie 2991*, April 2, 1908 (K. M.); Clemson, Oconee County, *House 3150*, March 20, 1907 (N. Y.).

ALABAMA: Auburn, *Earle*, April 10, 1901 (N. Y.); "Alabama," *Peters*, 1867 (N. Y.).

LOUISIANA: *Leavenworth*, 1845 (C).

TENNESSEE: Broad River, *Rugel* (D. C.).

ARKANSAS: *Leavenworth*, 1845 (C).

MISSOURI: Campbell, *Bush 6597*, April 19, 1912 (K. M.).

4. CAREX FLORIDANA Schwein. Ann. Lyc. N. Y. 1: 66. 1824

Carex lucorum var. *floridana* Chapm. Fl. S. E. U. S. 539. 1860.

Carex nigro-marginata var. *subdigyna* Böckl. Linnaea 41: 220. 1877.

Carex nigro-marginata var. *floridana* (Schwein.) Kükenth. in Engler, Pflanzenreich 4^{20}: 444. 1909.

Culms very slender, or capillary, erect or spreading, from very short to 2 dm. high, roughened on the angles, exceeded by the leaves, coming up in small clumps and long-stoloniferous, slightly filamentose at base. Leaves largely basal, those on the culms abortive or very short, the basal leaves 2–3 dm. long, 1–2 mm. wide, flat or somewhat involute (especially near the base), more or less glaucous and roughened; staminate spike one, terminal (but exceeded by the contiguous pistillate spikes), very short and inconspicuous, few-flowered, sessile, 3–5 mm. long, 0.75 mm. wide, the closely appressed scales lanceolate, obtuse, with green midrib and white hyaline margins; pistillate spikes two, sessile, very

close together, short-oblong, 4–8 mm. long, 2.5–4 mm. wide, 4–8-flowered, the perigynia appressed-ascending; bracts lanceolate or ovate-lanceolate, white-hyaline with green midrib, acuminate or cuspidate, shorter than the subtended spike; scales oblong or ovate-oblong, acuminate to obtusish, white-hyaline with green midrib, rather wider but shorter than the perigynia; perigynia puberulent, spindle-shaped, 3.25 mm. long, the body oval, compressed-orbicular in cross-section, 1.5 mm. long, 0.75 mm. broad, tapering to the stipitate base 1 mm. long, and rather abruptly into the slender beak 0.75 mm. long, the orifice entire or nearly so, the body nerveless except for the prominent decurrent edges of the beak; achenes normally lenticular, closely fitting the perigynia, the face oblong-elliptic, 1.75–2 mm. long, 1 mm. wide; stigmas two.

SPECIMENS EXAMINED:

GEORGIA: Rocky Comfort Creek, Louisville, Jefferson Co., *Harper 2105*, April 9, 1904 (N. Y.).

FLORIDA: Jacksonville, *Curtiss 4128*, April 3, 1893 (C), *4639*, March 24, 1894 (C), *6127*, March 31, 1898 (K. M.); Hibernia, *Canby*, March 1869 (C); "Florida," *Chapman* (N. Y. and C); "Florida," *Keeler* (C); Banks of Little River, *Chapman* (C); West Florida, *Chapman*, 1836 (C); Apalachicola, *Biltmore 1783* (N. Y.); "Florida," *Chapman*, from Dr. Lemann, 1847 (N. Y. ex herb. Boott).

LOUISIANA: Jackson, *Ingalls*, February (C); *Hale 707* (C).

MISSISSIPPI: Ocean Springs, *Earle*, Feb. 1889, very young (N. Y.).

TEXAS: Big Sandy, *Bush 2877*, April 7, 1902 (N. Y.).

5. CAREX DEFLEXA Hornem. Plantelaere, ed. 3, 1: 938. 1821

Carex varia var. *minor* Boott, in Hook. Fl. Bor.-Am. 2: 223 (in part). 1840.

Carex pilulifera var. *deflexa* Drej. Rev. Crit. Car. Bor. 54. 1841.

"*Carex Novae-Angliae* Schw." Boott, Ill. Car. 2: 96 (in part). 1860.

Carex pilulifera forma, Böckl. Linnaea 41: 216. 1877.

Carex deflexa var. *Deanei* Bailey, Mem. Torrey Club 1: 42. 1889.

Clumps small or medium-sized, stoloniferous, the rootstocks slender, horizontally creeping, branching; culms 3–10 cm. high, very slender, exceeded by the leaves, smooth, the fertile mostly phyllopodic. Fertile culms with several leaves with well-developed

blades inserted towards the base, the blades ascending, 1 mm. wide, usually less than 6 cm. long, roughened on the margins and towards the apex; leaves of sterile culms more numerous and with longer and somewhat wider blades; staminate spike solitary, erect, sessile, 2–4 mm. long, 0.5–1 mm. wide, inconspicuous and often exceeded by the closely contiguous pistillate spikes, the scales ovate-lanceolate, closely appressed, acute, straw-colored with hyaline margins and tinged with reddish brown; pistillate spikes one or two, sessile or short-peduncled, approximate, suborbicular or short-oblong, 2–4 mm. long, 3 mm. wide, containing about 2–8 ascending perigynia, normally with an additional, widely separated, basal spike; lower bract 5–10 mm. long, not sheathing and hardly colored at base; the upper much shorter; scales ovate, acute or short-acuminate, wider but shorter than the perigynia, tinged with reddish brown, the midrib green and the margins hyaline; perigynia puberulent, obovoid, obtusely triangular, nerveless or nearly so, the body 1.5 mm. long, 1 mm. wide, tapering to a stipitate base 1 mm. long, and abruptly contracted into a short (0.5 mm. long) beak with emarginate or shallowly bidentate orifice; achenes triangular (rather obtusely), short-oval, 1.5 mm. long; stigmas three.

The smaller forms of *Carex varia* Muhl. often resemble forms of *Carex deflexa* in which the basal spikes are not developed. They are, however, strongly cespitose and have squamiform bracts, which are normally hyaline-margined at base and do not usually exceed the culms.

SPECIMENS EXAMINED:

ARCTIC AMERICA: Norway House, *Richardson* (N. Y. and C.).

QUEBEC: Montmorency Falls, *Macoun 67592*, June 28, 1905 (N. Y.); Calumet, *Macoun 7405*, June 9, 1891 (D. C.).

ONTARIO: Sudbury Junction, *Macoun 30979*, May 24, 1884 (D. C.).

NEW BRUNSWICK: Kent County, *Brittain 30974*, 1888 (D. C.); Prince Edward Island, *Macoun 10702*, June 26, 1888 (D. C.).

NOVA SCOTIA: Truro, *Macoun 10704*, June 12, 1883 (D. C.).

BRITISH COLUMBIA: Latitude 54°, *Macoun 30970*, June 10, 1875 (D. C.); McCloud's Lake, *Macoun 30972*, June 24, 1875.

MAINE: Mt. Desert Island, *Faxon*, June 23, 1891 (N. Y.); Orono, *Fernald*, May 15, 1902 (N. Y.; K. M.); and May 29, 1890 (C.); Ft. Fairfield, *Fernald 149*, July 6, 1893 (C.); Mt. Desert

Island, *Rand*, June 21 and 23, 1891 (C.); Piscataquis County, *Fernald 269*, July 5, 1895 (C.).

NEW HAMPSHIRE: Franconia, *Faxon*, June 9, 1893 (N. Y.); Lisbon, *Graves*, June 10 and 13, 1893 (C.); Crawford Notch, *Faxon*, June 7, 1878 (C.); Wing Road, *Pringle*, June 4, 1878 (B).

VERMONT: Ripton, *Brainerd*, May 25, 1878 (B); June 7, 1879 (B); June 10, 1892 (B; N. Y.); Ripton, *Brainerd & Eggleston*, June 9, 1898 (K. M.); Lyndon, July 2, 1875 (N. Y.); Groton, *Pringle*, June 13, 1879 (B).

NEW YORK: Lake Placid, *Peck*, June 12, 1897 (N. Y.); White Face Mountain, *Parry*, Aug. 1851 (C.).

MASSACHUSETTS: Hawley, *Forbes*, May 30, 1905 (K. M.).

MICHIGAN: Keweenaw County., *Farwell 745*, July 1, 1890 (C.).

6. CAREX BREVIPES W. Boott, in S. Wats. Bot. Calif. **2**: 246. 1880
Carex globosa var. *brevipes* W. Boott, in S. Wats. Bot. Calif. **2**: 485. 1880.
Carex deflexa var. *Boottii* Bailey, Mem. Torrey Club **1**: 43. 1889.
Carex pilulifera var. *Novae-Angliae* F. Kurtz, Bot. Jahrb. **19**: 419. 1894.
Carex Rossii var. *brevipes* (W. Boott) Kükenth. in Engler, Pflanzenreich 4^{20}: 452. 1909.

In dense clumps from stout, matted, ascending rootstocks, not stoloniferous, the culms from very short to 18 cm. high, phyllopodic, reddish-purple tinged and more or less strongly fibrillose at base, the longer exceeding the leaves, the shorter hidden at their base, slender, roughened on the angles above; sterile culms aphyllopodic. Leaves with well-developed blades 4–8 to a fertile culm, the blades flat with slightly revolute margins, 1.5–2.5 mm. wide, up to 15 cm. long, roughened towards apex; terminal spikes staminate, slender, short-peduncled or sessile, 4–12 mm. long, 2.5 mm. wide, several–many-flowered, the scales ovate, acute or cuspidate, about 3-nerved, reddish- or light purplish-brown with lighter center and narrow hyaline margins; pistillate spikes 3–5, usually 10–20-flowered, the upper one or two approximate, from sessile to strongly peduncled, the others widely separated, basal, long-peduncled, the perigynia in several ranks, ascending; bract of lower non-basal spike leaflet-like, exceeding inflorescence, green, slightly purplish-auricled at base; scales ovate, acute to cuspidate, 1–3-nerved, green with narrow

hyaline margins and more or less strongly purplish-tinged, about the width of but shorter than mature perigynia, exposing the upper part; perigynia small, 2.5 to nearly 3 mm. long, 1.25 mm. wide, green, puberulent, the body little longer than wide, obscurely triangular in cross-section, 2-ribbed, otherwise nerveless, from short to rather strongly stipitate, abruptly contracted into the slender, minutely serrulate, slightly colored or hyaline-tipped shallowly bidentate beak 0.25–0.75 mm. long; achenes triangular with strongly convex sides closely enveloped by perigynia, nearly 2 mm. long, truncate at apex, round-tapering at base; style short and slender; stigmas three.

This species, originally collected in the Sierra Nevada Mountains of California, has no immediate relationship with *Carex globosa* Boott, to which it has been referred. As pointed out by Prof. Bailey, its real relationship is with *Carex deflexa* Hornem. and its allies. It resembles real *Carex deflexa* in its small perigynia, 2.5–3 mm. long with shallowly bidentate beak. It, however, is densely cespitose with stout rootstocks, while *Carex deflexa* is stoloniferous and has slender rootstocks. The staminate spikes in the plant of the Sierra Nevadas are more developed, the perigynia seem less strongly stipitate, the spikes are usually more flowered, and the plant is much stiffer. *Carex Rossii*, with larger deeply bidentate perigynia, seems constantly different.

SPECIMENS EXAMINED:

CALIFORNIA: "Lake Tahoe to Bear Valley," *Kellogg*, and "Rocky Mts. California," *Kellogg* (type sheets in Gray Herbarium); Sierra Nevada, *Braman & Kellogg*, June 9, 1870 (N. Y.); Sierra Nevada Mts., El Dorado County, *Brainerd 116*, July 19, 1897 (H; Brainerd).

WASHINGTON: Wenatchee Mts., Kittitas County, *Elmer 453*, June 28, 1897 (Piper).

7. CAREX ROSSII Boott, in Hook. Fl. Bor.-Am. 2: 222. 1840
Carex Novae-Angliae var. *Rossii* Bailey, Bot. Gaz. 10: 207. 1885.
Carex deflexa var. *Rossii* and var. *media* Bailey, Mem. Torrey Club 1: 43. 1889.
Carex Novae-Angliae var. *deflexa* Bailey, Proc. Am. Acad. 22: 124. 1886.
Carex deflexa var. *Farwellii* Brit., Brit. & Br. Ill. Fl. 1: 334. 1896.

Carex Farwellii (Brit.) Mackenzie, Bull. Torrey Club 37: 244. 1910.

Clumps medium-sized, densely or loosely cespitose, hardly stoloniferous, the rootstocks ascending; culms 5–20 cm. high, slender, usually exceeding the leaves, smooth or slightly roughened under the inflorescence, aphyllopodic or phyllopodic; basal spikes usually numerous. Fertile culms with several leaves with well-developed blades inserted towards the base, the blades ascending, 1–2 mm. wide, usually less than 6 cm. long, roughened on the margins and towards the apex; leaves of sterile culms more numerous and with longer and somewhat wider blades; staminate spike sessile or nearly so, erect, 3–8 mm. long, 1 mm. wide, exceeding the contiguous pistillate spike, the scales ovate-oblong, closely appressed, acutish, with green midrib and hyaline margins and strongly tinged with reddish brown; pistillate spikes one or two, sessile or short-peduncled (and with some additional widely separated basal ones), approximate or somewhat separate, suborbicular or short-oblong, 3–5 mm. long, 3–4 mm. wide, containing 3–10 ascending perigynia; lower bract 0.5–5 cm. long, not sheathing and hardly colored at base; the upper much shorter; scales ovate, acute to acuminate, or cuspidate, wider but shorter than the mature perigynia, strongly tinged with reddish- or purplish-brown, the midrib green and the margins hyaline; perigynia short-pubescent, 3–4.5 mm. long, obovoid, obtusely triangular, 2-ribbed but otherwise nerveless or nearly so, the body 1.5–2.5 mm. long, 1 mm. wide, tapering to a stipitate base 0.5–1.5 mm. long, and abruptly contracted into a bidentate beak 0.75–1.25 mm. long; achenes triangular (rather obtusely), short-oval, 1.5 mm. long; stigmas three.

This characteristic species of the western mountains has been given a great deal of study by me in an endeavor to ascertain definitely whether it represented an aggregate of more than one species or not. As a result I have come to the conclusion that but one variable species is represented and that the notable variations shown in individual plants are to be explained by environmental conditions. The species varies from densely cespitose in alpine or subalpine situations to loosely cespitose in more protected localities; these more loosely cespitose plants have the leaf-blades of the sterile culms much more developed and in all respects show a stronger vegetative growth; the scales of the basal spikes are inclined to be strongly cuspidate and the perigynia range in length from 3.75 to 4.5 mm. with a beak as long as the body. Such plants answer to *Carex Farwellii* and are quite dif-

ferent in appearance from the densely cespitose plants with much less developed vegetative growth, acute scales, and perigynia ranging from 3 to 4 mm. in length, with beak shorter than the body, which represent the other extreme of the series. However, all kinds of intermediate combinations appear, and make separation impossible except arbitrarily.

Other plants with narrow involute leaves collected in very dry situations also look quite different, but their peculiar aspect seems wholly due to their dried-up condition, as no structural differences have been found.

The species as here treated ranges from Vancouver Island and the Canadian Rockies south through Washington and Oregon to the higher Sierras of California and eastward in the higher mountains of Nevada and Utah. It seems common in Colorado, Wyoming, Montana, and Idaho. It has been found in northern Michigan. It is to be expected in northern New Mexico and possibly Arizona, and its northern range in western Canada is yet to be ascertained.

SPECIMENS EXAMINED:

CANADA: Rocky Mt. Park, *Macoun 64056*, July 8, 1904 (N. Y.); between Kettle and Columbia Rivers, *Macoun 63318*, June 6, 1902, and *63319*, July 9, 1902 (N. Y.), and *63320*, July 19, 1902 (N. Y.); Nanaimo, Vancouver Island, *Macoun 76742*, July 13, 1908 (N. Y.); Medicine Hat, Assiniboia, *Macoun 7402*, June 4, 1894 (C.); Mountain Post, Assiniboia, *Macoun 10780*, June 11, 1895 (N. Y., H); Revelstoke, *Shaw 834*, July 6, 1905 (N. Y.); Revelstoke, *Macoun 57A*, May 19, 1890 (C.); Lake Louise, *Macoun 64055*, July 20, 1904; Mt. Arrowsmith, *Rosendahl 2023*, June 28, 1907 (N. Y., H); Qu'Appelle Valley, *Macoun 49*, June 22, 1879 (H); Yale, *Macoun*, June 17, 1876 (H); Grand Valley, *Macoun 261*, June 16, 1880 (H); Trail to Asalkan Glacier, British Columbia, *Brainerd*, Aug. 11, 1897 (B); Vancouver, *Macoun*, July 27, 1887 (B); Calgary, *Macoun 25460*, June 7, 1897 (D. C.); Mt. Arrowsmith, Vancouver Island, *Macoun 30969*, July 17, 1887 (D. C.); Rogers Pass, Selkirk Mts., *Macoun 30968*, July 29, 1890 (D. C.); Elbow River, Rocky Mts., *Macoun 25461*, July 15, 1897 (D. C.); Esquimault, Vancouver Island, *Macoun 376*, June 9, 1893, and

Mt. Benson, *Macoun 377*, July 10, 1893 (D. C.); Nanaimo and Horne Lake, Vancouver Island, *Macoun 20286*, June 4, 1887, and *10706*, July 25, 1887 (D. C.); Kananaskis, Rocky Mts., *Macoun 32016*, June 15, 1885 (D. C.); Spy Hill, Saskatchewan, *Macoun 72789*, July 1, 1906 (D. C.); Clearwater River, *Macoun 32007*, July 8, 1888 (D. C.); Lytton, British Columbia, *Macoun 32008*, April 17, 1889 (D. C.); New Westminster Junction, British Columbia, *Macoun 80878*, April 19, 1889 (D. C.).

WASHINGTON: Bingen, *Suksdorf*, May 12, 1909 (N. Y.); Mt. Paddo, *Suksdorf*, Aug. 9, 1909 (N. Y.); Olympic Mts., *Elmer 2718*, June 1900 (N. Y., Piper); Mt. Rainier, *Piper 2537*, Aug. 15, 1895 (Piper, N. Y.); West Klickitat County, *Suksdorf 276*, April 30, 1885 (C.); "Washington," *Henderson*, 1892 (C.); Mt. Adams, *Howell*, Aug. 15, 1882 (H); Cascade Mts., *Allen 168*, June 4, 1895 (N. Y., H, Piper); Klickitat River, *Suksdorf 48*, June 2, 1883 (H); Cascade Mts., *Vasey*, 1889 (Piper); Whitman County, *Piper 3094*, July 20, 1899 (Piper); Blue Mts., *Horner 480*, July 29, 1897 (Piper); Mt. Rainier, *Piper 2552*, Aug. 1895 (Piper); Mt. Adams, *Henderson 2094*, Aug. 10, 1892 (Piper); Olympia, *Henderson*, 1892 (Piper); Hangman Creek, Spokane County, *Sandberg & Leiberg 30*, May 17, 1893 (Piper); Wenatchee, *Brandegee 1145*, 1883 (D. C.).

OREGON: Union County, *Cusick 1322*, 1886 (Piper); "Oregon," *Cusick* (Piper); Wallowa Mts., *Sheldon 8535*, July 12, 1897 (K. M.); Lake County, *Eggleston 6850*, June 5, 1911 (N); Mt. Adams, *Chickering*, Aug. 1882 (D. C.).

CALIFORNIA: Sierra Nevada, *Kellogg* (N. Y.); Cisco, Sierra Nevada, *Kellogg*, June 19, 1870 (H); Hat Creek, Shasta County, *Eggleston 7382, 7434, 7435*, July 31, 1911 (N) also *7485*, Aug. 2, 1911 (N); Summit, Placer County, *Heller 9853*, July 16, 1909 (K. M.); Pyramid Peak, El Dorado County, *Hall & Chandler 4749*, Aug. 1–2, 1903 (H).

UTAH: Big Cottonwood Canyon, Salt Lake Co., *Garrett 1658*, Aug. 21, 1905 (N. Y.); Marysvale, *Jones 5343*, May 31, 1899 (N. Y., K. M.); Alta, *Jones 1204*, Aug. 7, 1879 (C.); Hornwood Canyon, *Watson 1260*, July 1869 (C.).

IDAHO: Kootenai County, *Sandberg, MacDougal & Heller 234*, May 23, 1892, and *841*, Aug. 5, 1892 (N. Y.); Nez Perces County, *A. A. & E. G. Heller 3388*, July 9, 1896 (C., Piper); Kootenai

County, *Sandberg*, July 1887 (N. Y.); Sweetwater, *Heller*, July 1896 (K. M.).

MONTANA: Bozeman, *Flodman 289*, July 7, 1896 (N. Y.); Little Belt Mts., *Flodman 288*, Aug. 1896 (N. Y.); Helena, *Kelsey*, July 12, 1892 (N. Y.); Little Belt Mts., *Rydberg 3377, 3892*, Aug. 1896 (N. Y.); Spanish Basin, Madison Range, *Flodman 287*, July 18, 1896 (N. Y.).

COLORADO: *Vasey* (N. Y.); Chamber's Lake, *Baker*, July 13, 1896 (N. Y.); La Plata Mts., *Baker, Earle & Tracy 685*, July 14, 1898 (N. Y.); Chamber's Lake, *Crandall*, July 25, 1894 (N. Y.); Chamber's Lake, *Colo. Agri. College 2549*, July 28, 1889 (N. Y.); Beaver Creek, *Colo. Agri. College 2558*, July 19, 1898 (N. Y.); Pagosa Peak, *Baker 237*, Aug. 1899 (N. Y.); Cameron Pass, *Baker*, July 14, 1896 (N. Y., C.); Middle Park, *Beardslee*, Aug. 1892 (N. Y.); Colorado Springs, *Jones 59*, May 14, 1878 (N. Y., C., B); Silver Plume, *Rydberg 2416*, and *Shear 669*, Aug. 21, 1895 (N. Y.); Twin Lakes, *Wolfe 1058*, 1873 (C.); Mt. Helen, *Mackenzie 307*, Aug. 1901 (K. M.).

WYOMING: Big Horn Mts., Sheridan County, *Tweedy 2246*, July 1899 (N. Y.); Black Rock Creek, Teton Forest Reserve, *Tweedy 401*, Aug. 1897 (N. Y.); Teton Pass, *Merrill & Wilcox 1249*, July 13, 1901 (N. Y.); Madison Canyon, *A. & E. Nelson 6761*, Aug. 29, 1899 (N. Y.); Battle Lake, *A. Nelson 3046*, Aug. 16, 1897 (N. Y.); Yellowstone Park, *Williams*, 1888 (N. Y.); Yellowstone Park, *A. & E. Nelson 6361*, Aug. 8, 1899 (N. Y., K. M.); La Plata Mines, *A. & E. Nelson 5148*, Aug. 25, 1898 (K. M.); Ten Sleep Lakes, *Nelson 2972*, Aug. 19, 1897 (K. M.).

MICHIGAN: Clifton, Keweenaw Co., *Farwell 244*, June, 1890 (Col., H).

8. **Carex pityophila** sp. nov.

In large dense clumps from slender tough ascending forking rootstocks, not stoloniferous, the culms from very short to 15 cm. high, aphyllopodic, reddish brown and more or less fibrillose at base, usually shorter than leaves, slender, very rough on the sharp angles; sterile culms aphyllopodic. Leaves with well-developed blades 5–10 to a fertile culm, the blades involute but flat above with slightly revolute margins, slender, at flowering time 0.75–1.5 mm. wide, 2–25 cm. long, much roughened; terminal spike staminate, slender, 4–8 mm. long, 1.5 mm. wide, more or less

strongly peduncled, few–several-flowered, the scales ovate or obovate, obtuse to acute, 1–3-nerved, purplish brown with lighter midvein and conspicuous hyaline margins; pistillate spikes 2–5, usually 2–5-flowered, the upper one or two approximate or little separate, sessile or peduncled, the others widely separate, basal and strongly peduncled, the perigynia erect-ascending, the rachis zigzag; bract of upper spike green, scarcely sheathing, slightly purplish-tinged at base, normally exceeding inflorescence; scales ovate, acute to short-cuspidate, with several-nerved green center and hyaline margins and more or less strongly purplish-brown tinged, nearly as long and nearly as wide as, but not enveloping or concealing perigynia; perigynia sparingly puberulent, green, 3.5–4.5 mm. long, the body short- to long-oval, 2.25–3 mm. long, 1.75 mm. wide, 2-ribbed and otherwise nerveless or nearly so, triangular-suborbicular in cross-section, strongly stipitate (0.75–1 mm.), abruptly contracted into the scarcely ciliate-serrulate, hyaline-tipped, obliquely cut, in age shallowly bidentate beak, 0.75–1 mm. long; achenes triangular with strongly convex sides, closely enveloped by perigynia, 2–2.75 mm. long, nearly 1.75 mm. wide, truncate and slightly apiculate at apex, rounded at base; style slender, not enlarged at base, readily detached; stigmas three.

The type specimen was collected by Mr. W. W. Eggleston (*6605*) southeast of Tierra Amarilla, Rio Arriba County, New Mexico, in the piñon belt at an altitude of 2,320 meters in the spring of 1911 (sheet 660821, United States National Herbarium). His numbers *6536*, *6540*, *6542* and *6610*, collected in the same locality, also represent this species. Fendler's *889* collected in New Mexico in 1847 (H) also belongs here.

Carex geophila differs in the characters given in the key and in addition the present species has narrower leaves, more slender staminate spikes, few-flowered pistillate spikes, strongly reddened culm bases and scarcely ciliate-serrulate perigynium beak.

9. **Carex geophila** sp. nov.

In large very dense clumps from tough, rather slender, much branched rootstocks, not stoloniferous, the culms from very short to 10 cm. high, phyllopodic, brownish and very conspicuously and strongly fibrillose at base, much shorter than and mostly hidden among bases of leaves, slender, very rough on the sharp angles; sterile culms strongly aphyllopodic. Leaves with well-developed blades 5–10 to a fertile culm, the blades flat with slightly revolute margins, 1.5–2.5 mm. wide, 2–15 cm.

long, much roughened; terminal spike staminate, slender, 5–9 mm. long, 2.5 mm. wide, more or less strongly peduncled, several–many-flowered, the scales ovate, acute or short-acuminate, many-striate, purplish brown with lighter center and conspicuous white-hyaline margins; pistillate spikes 2–5, usually 5–15-flowered, the upper one or two usually approximate, sessile or short-peduncled (sometimes absent), the others widely separated, basal and strongly peduncled, the perigynia in several ranks, ascending; bract of upper spike (where spike is present) well developed, green, somewhat sheathing, slightly brownish-red tinged, shorter than inflorescence; scales ovate, acute to short-cuspidate, those of the upper spikes reddish brown with 3-nerved green center and white-hyaline margins, those of lower spikes slightly if at all reddish-brown tinged, all from slightly shorter to slightly longer and wider than but not enveloping or nearly concealing perigynia; perigynia puberulent, green, 3.25–4 mm. long, the body suborbicular, 2.25–2.5 mm. long, 1.75 mm. wide, 2-ribbed, otherwise nerveless or more or less strongly nerved at base on one face, nearly orbicular in cross-section, strongly stipitate (0.5–0.75 mm.), abruptly contracted into the serrulate, slightly hyaline or purplish-tipped bidentate beak, 0.5–0.75 mm. long; achenes triangular with strongly convex sides, closely enveloped by perigynia, about 2.25 mm. long, nearly 1.75 mm. wide, truncate and slightly apiculate at apex, round-tapering at base; style slender, not enlarged at base, readily detached; stigmas three.

The type specimen, collected by Mr. W. W. Eggleston (*6584*) at Tierra Amarilla, Rio Arriba County, New Mexico, in the spring of 1911, is in the United States National Herbarium (sheet 660800). His numbers *6614*, *6474*, *6466*, *6550*, *6556*, *6458*, and *6593* from the same locality also belong here, as does also his *6655* collected near Chama, Rio Arriba County. The species is also represented by a specimen in the Gray Herbarium, collected by Dr. Greene April 22, 1880 (deep shady canyon of Mineral Creek in the Mogollon Mountains).

10. **Carex brevicaulis** sp. nov.

In dense clumps, stoloniferous, the culms phyllopodic, 5–10 cm. high, slender, exceeded by the leaves, sharply triangular, very rough on the angles, reddish brown and more or less fibrillose at base. Leaves with well-developed blades 6–10 to a fertile culm, clustered near base, the blades flat, 1.5–3.5 mm. wide, usually 2.5–7.5 cm. long, roughened above and towards apex; leaf-blades of sterile culms 5–12 cm. long; terminal spike stam-

inate, few-flowered, short-peduncled, 6–9 mm. long, 1.5–2 mm. wide, the scales narrowly ovate, acute to short-cuspidate, reddish brown with light-colored midrib and center and white-hyaline, non-ciliate margins; lateral spikes 2, 3 or 4, pistillate, 4–6 mm. long and nearly as wide, the uppermost sessile near base of staminate, the second (if present) sessile and somewhat remote, the others far remote, basal, slender-peduncled, the maturing perigynia 1–4, erect-ascending, the upper flowers not developing; bract of upper spikes leaflet-like, shorter than or rarely slightly exceeding culm, widened at base into reddish brown auricles with hyaline margins; scales ovate, acute to short-cuspidate, reddish brown with light-colored midrib and center and white-hyaline, non-ciliate margins, narrower and shorter than the mature perigynia; perigynia about 4 mm. long, loosely short-pubescent, more or less yellowish-brown tinged, stipitate, the body globose, 2.25 mm. wide, 2-ribbed, abruptly contracted into the slender serrulate, rather shallowly bidentate beak 1 mm. long; achenes triangular-globose, the sides strongly convex, closely enveloped by perigynia, 2 mm. wide and slightly longer, abruptly rounded at base and apex, slightly stipitate; style slender, enlarged at base, deciduous, short; stigmas three.

SPECIMENS EXAMINED:

BRITISH COLUMBIA: Victoria, *Macoun 76706*, June 12, 1908 (N. Y.); Vancouver, *Macoun*, May 30, 1873 (H); *Macoun 32014*, May 8, 1875 (D. C.).

WASHINGTON: Whidbey Island, *Gardner 343*, May 29, 1897 (Piper).

OREGON: Yaquina Bay, *Howell 2994*, May 1886, type (N. Y.); Wilkes Exped. 1834–1842 (C.).

CALIFORNIA: San Francisco, *Kellogg*, May 1880 (N. Y.).

11. **Carex microrhyncha** sp. nov.

In large stools, spreading by short stolons; culms from very short to 15 cm. high, mostly much exceeded by the leaves, slender, triangular, rough on the angles, reddish-brown tinged and strongly fibrillose at base, phyllopodic; sterile culms phyllopodic, terminating the short stolons, their sheaths little if at all filamentose. Leaves numerous, erect or ascending, light green, from very short to 20 or 30 cm. in length, at flowering time 1.5–2.5 mm. wide, in age up to 3 mm. wide, flat with somewhat revolute margins, very rough above; terminal spike staminate, sessile or short-peduncled, 5–10 mm. long, 1.5–2.5 mm. wide, the scales obovate,

obtuse or acute, reddish brown with lighter midvein and hyaline margins; pistillate spike usually present at base of staminate, sessile or short-peduncled, globose-oblong, 3.5 mm. wide, 4–7 mm. long, its bract squamiform, reddish-brown tinged and exceeded by culm, the basal spikes 2 or 3, subglobose, 4–6 mm. long, 3.5–4.5 mm. wide; scales broadly ovate acute or short-cuspidate, about length of but wider than perigynia and largely concealing them, strongly several-nerved, greenish or hyaline; perigynia 2.25–3.25 mm. long, the body short-oval, triangular-orbicular in cross-section, 1.25 mm. wide, short-pubescent, 2-ribbed, otherwise nerveless, tapering or contracted into a short stipitate base 0.5 mm. long, abruptly contracted into the short (0.5 mm. long) beak, less than half length of body, the beak 2-edged, hyaline-tipped, at most obscurely bidentate; achenes triangular, oblong-obovoid, filling perigynia, minutely stipitate, dull or silvery blackish, the superficial cells conspicuous, the sides convex and angles blunt and prominent; style slender; stigmas three.

This species bears such a strong superficial resemblance to *Carex abdita* Bicknell that it was not until I came to examine the achenes that I found out that the plants were distinct. The achenes in fact much more resemble those of true *Carex umbellata* Schk., as described by Mr. Bicknell (Bull. Torrey Club **35**: 491), and as the perigynia are those of *Carex abdita*, I began to doubt the excellent achene characters brought out by him. However, still further study brought out the differences shown in the key in the manner of growth and in the sterile shoots as compared both with *C. abdita* and *C. umbellata*. The perigynia, too, are much more concealed by the scales than in either of these species.

SPECIMENS EXAMINED:

MISSOURI: Dodson, Jackson County, *Mackenzie*, May 10, 1896, and May 14, 1899, type (K. M.); St. Louis, *Riehl*, 1838 (C); St. Louis County, *Eggert*, April–May, 1887 (H).

INDIAN TERRITORY: Limestone Gap, *Butler* (H).

TEXAS: Blanco River (Dew. Herb., H); "Texas," *Leavenworth* (C); Dallas, *Reverchon*, March 1877 (C).

12. CAREX ABDITA Bicknell, Bull. Torrey Club **35**: 492. 1908

Carex umbellata var. *brevirostris* Boott, Ill. Car. **2**: 99. *pl. 294*. 1860.

Very densely cespitose, culms from very short to 15 cm. high,

mostly much exceeded by the leaves, slender, triangular, rough on the angles, reddish-brown tinged and strongly fibrillose at base, phyllopodic; sterile culms aphyllopodic, erect, the sheaths filamentose. Leaves numerous, the blades erect or ascending, light green, from very short to 20 or 30 cm. in length, at flowering time about 1.5 to 2.5 mm. wide, in age up to 3 mm. wide, flat with somewhat revolute margins, very rough above; terminal spike staminate, sessile or short-peduncled, 5–10 mm. long, 1.5–2 mm. wide, the scales obovate, obtuse or acute, reddish brown with lighter midvein and hyaline margins; pistillate spike usually present at base of staminate, sessile or short-peduncled, globose-oblong, 3.5 mm. wide, 4–7 mm. long, its bract squamiform, reddish-brown tinged and exceeded by culm, the basal spikes 2 or 3, short, oblong, 5–9 mm. long, frequently staminate at apex; scales ovate, abruptly acute or acuminate, longer and wider than perigynia but not concealing them, strongly several-nerved, greenish or hyaline, the upper at least reddish-brown tinged; perigynia 2.25–3.25 mm. long, the body subglobose, triangular-orbicular in cross-section, 1.25 mm. wide, short-pubescent, 2-ribbed, otherwise nerveless, tapering or contracted into a short-stipitate base, 0.5 mm. long, abruptly contracted into the short (0.5–1 mm. long) beak, less than half length of body, the beak 2-edged, hyaline-tipped, at most obscurely bidentate; achenes triangular, orbicular-obovoid, filling perigynia, brownish, sessile, shining, irregularly pitted, the sides convex and angles sharp and narrow; style slender; stigmas three.

Differs from *Carex umbellata* in the small, short-beaked, obscurely bidentate perigynia, and in the achenes.

A northern species extending south to Delaware and Indiana.

SPECIMENS EXAMINED:

CANADA: Quesnelle, *Macoun*, May 29, 1874 (H); Norway House, *Richardson 323* (H); Rocky Mts., *Richardson* (H); Carlton House (H); Norway House, *Richardson* (H); Victoria, Vancouver Island, *Macoun 16673*, May 7, 1875 (D. C.); Fraser River Valley, *Macoun 32015*, May 18, 1875 (D. C.); "Rocky Mts.," *Drummond* (D. C.); Hastings County, Ontario, *Macoun 32019*, June 15, 1865 (D. C.).

MAINE: Vassalboro, *Fernald & Chamberlain*, May 17, 1902 (K. M.); Bangor, *Knight*, May 14, 1905 (K. M.).

VERMONT: Snake Mt., *Brainerd*, June 11, 1897 (B).

NEW HAMPSHIRE: Mt. Willard, *Faxon*, June 7 (N. Y.).

MASSACHUSETTS: Deerfield, *Cooley* (C); Boston, *W. Boott* (D. C.).

CONNECTICUT: Bridgeport, *Eames*, May 28, 1908 (N. Y.).

RHODE ISLAND: Thurber, May 1846 (N. Y.).

NEW YORK: Richmond Hill, Long Island, *Bicknell*, May 11, 1904 (N. Y.); Jamaica, *Bicknell*, May 19, 1905, type (N. Y.); Sparrow Bush, along Delaware River, *Britton*, May 30, 1903 (N. Y.); Yonkers, *E. C. Howe*, May 1876 (N. Y.); Whitesboro, Oneida County, *Haberer 5176*, June 19, 1883 (N. Y.); New York, *LeRoy* (C.).

NEW JERSEY: Hoboken, *Torrey*, May 1824 (C.); Andover Junction, *Mackenzie 4869*, May 1911 (K. M.); Columbia, *Mackenzie*, May 1913 (K. M.); Cranberry Lake, *Mackenzie 2608*, June 9, 1907 (K. M.); south of Port Jervis, *Mackenzie 4584*, May 30, 1910 (K. M.).

DELAWARE: Townsend, *Commons*, May 17, 1883 (N. Y.).

INDIANA: Ripley County, *Deam 10578*, May 19, 1912 (K. M.); Clarke County, *Deam 10494*, May 8, 1912 (K. M.); Wells County, *Deam*, April 30, 1899 (K. M.).

13. CAREX UMBELLATA Schkuhr, Willd. Sp. Pl. 4: 290. 1805
Carex umbellata var. *vicina* Dewey, Am. Jour. Sci. **10**: *pl. D. f. 13* 1826; **11**: 317. 1826.

Very densely cespitose, culms from very short to 15 or 20 cm. high, much exceeded by the leaves, triangular, rough on the angles, reddish-brown tinged and strongly fibrillose at base, phyllopodic; sterile culms aphyllopodic, erect, the sheaths filamentose. Leaves numerous and conspicuous, the blades from very short to 20 cm. long, at flowering time 1.5–2 mm. wide, in age wider, very rough, flat with somewhat revolute margins; terminal spike staminate, short-peduncled, 8–12 mm. long, 1.5–2.5 mm. wide, the scales obovate, obtuse or acute, reddish-brown with lighter midvein and hyaline margins; pistillate spike usually present at base of staminate, sessile or short-peduncled, globose-oblong, 3.5 mm. wide, 4–7 mm. long, its bract squamiform and exceeded by culm, the basal spikes oblong, 4–10 mm. long, 3.5–4.5 mm. wide; scales lance-ovate, short-cuspidate to acuminate, from slightly shorter to slightly longer and rather wider than the perigynia, but not concealing them, those on the shorter culms hyaline with green several-nerved center, those on the longer culms similar, but the margin tinged with reddish brown; perigynia 3.25–4.25 mm. long,

the body short-oval, triangular-orbicular in cross-section, about 1.75 mm. long and 1.4 mm. wide, short-pubescent, 2-ribbed, otherwise nerveless, abruptly short-(0.5 mm. long) stipitate, abruptly contracted into a beak about length of body, the beak 2-edged, hyaline-tipped, bidentate; achenes triangular, oblong-obovoid, filling perigynia, dull or silvery blackish, minutely roughened, the superficial cells conspicuous, sessile, the sides convex, and angles sharp and narrow; style slender; stigmas three.

Carex pennsylvanica Lam. and *Carex heliophila* Mackenzie at times develop pistillate spikes on subradical peduncles. The long stolons characteristic of these species afford the easiest means of distinguishing such specimens from *Carex umbellata* and its allies. It is possible that these specimens represent, to some extent at least, hybrids with the *Carex umbellata* group as they are treated by Kükenthal, but my own inclination is to regard them as above.

SPECIMENS EXAMINED:

CANADA: Bic, Rimouski County, Quebec, *Forbes*, June 23, 1905 (K. M.); Point Pleasant, Nova Scotia, *Macoun 16674*, June 18, 1883 (D. C.); Edmonton, Ontario, *White 32017*, May 24, 1893 (D. C.).

VERMONT: Middlebury, *Brainerd*, May 24, 1878, and June 9, 1891 (B); Winooski, *Brainerd*, June 5, 1897 (B); Chipman Hill, *Brainerd*, May 30, 1897 (B).

MICHIGAN: Port Huron, *Dodge*, June 3, 1894 (K. M.); Lake Harbor, *Umbach*, May 28, 1898 (K. M.); Orion, Oakland County, *Wheeler*, May 30, 1895 (C); Grand Lodge, *Wheeler 47*, May 5, 1890 (C).

MAINE: Orono, *Merrill*, June 5, 1898 (N. Y.); Orono, *Fernald*, June 30, 1890.

MASSACHUSETTS: South Ashburnham, *Forbes*, May 30, 1904; (K. M.); Manchester, *Chamberlain* (N. Y.); Cambridge, *Mrs. Britton*, May 12, 1889 (C); "Mass.," *Dewey* (D. C.).

NEW YORK: Yonkers, *E. C. Howe*, May 1880 (N. Y.); "New York," *Crawe* (C); "New York," *Gray*, 1846 (C); Highlands of New York, *Torrey* (C).

NEW JERSEY: High Point, Sussex County, *Mackenzie 4564* and *4571*, May 29, 1910 (K. M.); Tuckerton, *Mackenzie*, May 1911 (K. M.).

14. CAREX TONSA (Fernald) Bickn. Bull. Torrey Club 35: 492. 1908

Carex umbellata var. *tonsa* Fernald, Proc. Am. Acad. 37: 507. 1902.

Densely cespitose, freely short-stoloniferous; culms 2–15 cm. high, much exceeded by the leaves, sharply triangular, strongly roughened on the angles, strongly reddish-brown tinged and fibrillose at base, phyllopodic; sterile culms aphyllopodic, the sheaths little filamentose. Leaves numerous and conspicuous, the blades spreading, deep green, 2.5–4 mm. wide with revolute margins, 5–25 cm. long, rough towards the long attenuate apex; staminate spike 6–12 mm. long, 2–3 mm. wide, the obovate scales acute, reddish brown with greenish or straw-colored center and white-hyaline margin; pistillate spike occasionally present at base of staminate, sessile or nearly so, erect-ascending; basal pistillate spikes 2–3, on long slender peduncles, short-oblong, 6–10mm. long, 4.5–6 mm. wide, containing 3–20 closely packed appressed-ascending perigynia in several ranks; bract at base of uppermost spike setaceous, not sheathing, from much shorter than to slightly exceeding spike; scales conspicuous, ovate, short-cuspidate to acute, wider and from slightly shorter to slightly longer than perigynia, whitish or straw-colored hyaline, with green midrib, the upper often with purplish brown margins; perigynia 3.5–4.5 mm. long, the body broadly oval, 1.75 mm. long, 1.25 mm. wide, tapering into the stipitate base 0.75 mm. long and the beak 1.75–2.5 mm. long, the body compressed-orbicular and obscurely triangular in cross-section, 2-ribbed, otherwise nerveless or nearly so, very sparsely short-pubescent above and on the strongly 2-edged bidentate beak; achenes short-obovoid, triangular, filling perigynia, brownish, shining, pitted, the superficial cells inconspicuous, substipitate, 1.5 mm. long, closely fitting perigynia, the sides convex and angles sharp and narrow; style slender; stigmas three.

SPECIMENS EXAMINED:

CANADA: Lake Ellen, Ontario, *Macoun 32020*, July 1, 1884 (D. C.); "British N. W. America," *Richardson* (D. C.); Chalk River, Ottawa Valley, *Macoun 16675*, May 30, 1884 (D. C.); Cape à L'Aigle, Quebec, *Macoun 67594*, July 27, 1905 (D. C.); Truro, Nova Scotia, *Macoun 32018*, June 14, 1883 (D. C.).

MAINE: Orono, *Fernald*, May 15, 1902 (N. Y., K. M.); also May 29, 1890 and June 2, 1890 (C).

MICHIGAN: White Hall, *Wheeler*, June 27, 1900 (D. C.).

MASSACHUSETTS: South Dennis, *C. N. Brainerd*, May 1878 (B); Nantasket, *E. Brainerd*, June 11, 1896 (B).

RHODE ISLAND: Cumberland Mills, *Collins*, May 29, 1892 (C).

NEW YORK: Wading River, *E. S. Miller* (N. Y.); Valley Stream, *Bicknell*, May 23, 1908 (N. Y.); Woodmere, *Bicknell*, May 10, 1908 (N. Y.).

NEW JERSEY: South Lakewood, *Mackenzie 4544*, May 15, 1910 (K. M.); Tuckerton, *Mackenzie*, May 1911 (K. M.); Lakewood, *Torrey Club*, May 28, 1898 (N. Y.); "New Jersey," *Parker* (N. Y., D. C.); "New Jersey," *Knieskern* (N. Y.); Forked River, *Torrey Club*, May 29, 1896 (C); Tom's River, *Britton*, May 23, 1885 (C); Stelton, *Mackenzie 3024*, May 3, 1908 (K. M.); Yardville, *Mackenzie*, May 1913 (K. M.).

DISTRICT OF COLUMBIA: Tacoma Heights, *Williams*, March 26, 1898 (K. M.); *Holm*, May 1899 (D. C.).

NEW YORK CITY

The development and behavior of the chromosomes in the first or heterotypic mitosis of the pollen mother-cells of Allium cernuum Roth

DAVID M. MOTTIER AND MILDRED NOTHNAGEL

(WITH PLATES 23 AND 24)

It may seem to the reader of cytological literature that whoever offers a contribution upon *Allium* might well preface his remarks with an apology for so doing. However, certain favorable forms of both plants and animals will doubtless ever remain objects of investigation. On looking about for favorable material for class use, the senior author came upon a species of wild onion, common in certain localities in Indiana, namely, *Allium cernuum* Roth, a species which is regarded as more favorable than the much used *Allium Cepa*.

A study of mitotic phenomena has been made in both vegetative and microspore mother-cells, and the results obtained and conclusions reached differ so much in certain respects from those of Bonnevie ('11), as set forth in a recent contribution on *Allium Cepa*, that we have decided to present the results of our observations on the pollen mother-cells at this time, reserving an account of the process of nuclear behavior in vegetative cells for a future publication.

In describing the resting stage of the nucleus in the pollen mother-cell of *Allium Cepa*, Bonnevie ('11, 197) asserts that a number of threads radiate from a chromatin knot or lump (Chromatinknoten), being continued into the meshes of the nuclear net. "Vom Chromatinknoten sieht man eine Anzahl Fädchen, die in den Maschen des Kernnetzes ihre Fortsetzung finden, radiär ausstrahlen." With the disappearance of the anastomoses between these radiating threads, the latter gradually became more distinct throughout their entire length, at the same time appearing always zigzag or spirally twisted. Precisely the same structure is reported for the resting nucleus of somatic cells. Following this

structure there takes place (l. c. 197) a pairwise conjugation of the chromosomes, which finds its culmination in synapsis. This conjugation is accomplished by the lateral fusion in pairs of the threads radiating from the chromatin knots (l. c. fig. 20). Soon after this (l. c. 198) such nuclei become more irregular, for, in addition to the chromatin knots or lumps, there appear other dense accumulations of chromatin, so that, as a result, the original radial arrangement of the threads is no longer recognizable (l. c. fig. 21).

In the light of their own preparations as compared with Bonnevie's figs. 18–21, the writers are convinced that Bonnevie is describing the appearance of very poorly fixed and poorly stained nuclei. That Bonnevie has failed to distinguish between good and bad fixation is clear to the writers from the following (l. c. 198): "Ja, das Zusammenlaufen der Chromatinsubstanz kann soweit gehen, dass alles Chromatin des Kernes in einer einzigen, optisch schwer analysierbaren Masse zusammengeballt erscheint." This is true, but such phenomena do not represent normal steps in the mitotic process; they are largely artifacts. It is true, as has been pointed out some years ago by one of us (Mottier, '07, fig. 15), that chromatin granules may sometimes form accumulations either by themselves or grouped about the nucleolus, but such phenomena are to be regarded more on the order of chance occurrences than as representing significant and regularly appearing stages of the nucleus. It is conceivable that such accumulations of chromatin granules may be run together or fused by the reagents, and it is highly probable that the Chromatinknoten were formed in this manner. We do not find these masses of chromatin in our preparations. At any rate the Chromatinknoten of Bonnevie's figs. 18–21 are not to be regarded as of any consequence in the normal process of mitosis, as will be seen from what follows.

THE RESTING NUCLEUS AND SYNAPSIS

The nucleus of the resting stage in the pollen mother-cells of *Allium cernuum* Roth presents the well-known net or reticulum of linin upon which are distributed with more or less regularity the chromatin particles or granules. From one to several nucleoli of varying sizes are present. FIG. 1 illustrates the structure of

the nucleus in a pollen mother-cell soon after the last somatic division. The structure of the whole cell is the same as that of any somatic cell from any meristematic region. The growth period of both cell and nucleus now begins, and the very marked increase in the size of the nucleus as compared with that of the cell is very conspicuous in this as well as in other species of *Allium* (FIG. 2, 7, 8, 9). In FIG. 2 the nucleus is almost if not quite as large as it ever becomes. The nuclear reticulum is uniform, and the nucleoli may or may not be evenly spaced in the cavity of the nucleus. They do not lie in the same plane, and in making the drawing the focus was necessarily changed. FIG. 2 and all others represent rather thick sections of cells. Sometimes the chromatin granules form larger and smaller aggregates, which may be grouped about the nucleoli or removed from the latter, but we do not find large fused masses of chromatin such as Bonnevie has figured and described as "Chromatinknoten." A glance at FIG. 2 shows further that there may be a tendency to form a thread, that is, there will be seen stretches of linin in which the granules are arranged in lineal series. As pointed out by one of us (Mottier, '07) for *Lilium Martagon*, there is a tendency in *Allium cernuum* to form a delicate thread or spirem just before or as the nucleus passes into the synaptic contraction. FIG. 2 is about ready to begin the contraction of its net into the compact mass. FIG. 3 is a faithful attempt to illustrate the nuclear structure passing into synapsis, and FIG. 4 is a similar stage but includes the whole nucleus. These two figures were found in the same section of the loculus, in which were to be seen variously different stages of the early contraction. The writers wish to state most emphatically that there is no evidence of the fusion of two spirems during the contracting process. The spirem is formed directly from the nuclear network in the only way possible for a net to make a continuous thread, namely, by the breaking or dissolving of threads of certain meshes and the fusion of others. In the fusion of meshes several threads are seen to unite just as frequently and as certainly as one may find the fusion of only two threads. The appearance of the lateral union of two threads of certain meshes in several parts of the nucleus previous to synapsis is the strongest evidence, in the opinion of the writers, that those observers can bring forward

who hold to the doctrine that two spirems fuse side by side during, or prior to, synapsis and who deny that the somatic chromosomes are arranged end to end in a lineal series to make the continuous hollow spirem. These authors ignore the fact that three or more threads fuse in the formation of the spirem from the net as well as only two, and as will be pointed out in a subsequent paragraph, they omit from consideration and from their series of figures the most difficult and perhaps the most important steps in the formation of the bivalents from the hollow spirem.

FROM SYNAPSIS TO THE BIVALENTS

The stage of FIG. 4 passes directly into the closely contracted mass of FIG. 5. While the chromatin is still in this state, the thread gradually shortens and thickens into a heavy cord. Even before an appreciable loosening up of the synaptic ball it is readily seen that a thick spirem, or cord, is forming from the slender thread, and, as soon as the contracted mass loosens (FIG. 6), the correctness of this interpretation is beyond doubt. We have in our preparation transitional stages between FIG. 5 and 6, but it was not deemed necessary to include these in the series. The thick cord thus developed now becomes distributed throughout the nuclear cavity. In *Allium* it is relatively thick, apparently rather uniform in structure, though sometimes lumpy, and in many cases numerous delicate threads extend from the spirem to the nuclear membrane or between adjacent or parallel portions of the cord (FIG. 7, 8). A nucleolus is usually present. At this stage a longitudinal split may be sometimes seen, but this phenomenon is rather the exception than the rule (FIG. 8). This fission always closes up and the two halves become so closely applied or fused that the double nature of the thread, if really present, is completely concealed before any indication of cross segmentation is discernible.

Following the stage of the loose hollow spirem, the same undergoes a rearrangement before transverse segmentation, which results in a twisting, looping, and an entangling of its parts. This phenomenon found in the lilies and in other plants is known as the second contraction. In the lilies there is a central knotted or entangled portion of the spirem from which extend somewhat

radially loops and straight stretches of the cord, the latter with free ends. In *Allium cernuum* we do not find this typical appearance observed in *Lilium*. There is usually a tendency for the spirem to mass or become more closely entangled near the center of the nuclear cavity with a looping in the freer parts as shown in FIG. 10 and 11, which represent the less complicated condition, but, as a rule, the entanglement is so complicated that it is not possible to follow definitely more than a few loops or turns of the entire cord. If, for example, the spirem of FIG. 10 or 11 were bunched together more closely near the center with a greater twisting of the loops, we should have the more complicated state referred to above. The complexity of this step is increased by the fact that the spirem usually becomes more lumpy, or thicker places alternate with others more attenuated, just prior to, or as this rearrangement is ushered in (FIG. 9). Sometimes when the rearranged condition is not too confused, the spirem seems to be undergoing cross segmentation (FIG. 10), but whether this is the rule we are unable to say. It is certain, however, that in all, or in nearly all cases, the transverse segmentation of the spirem is accomplished during the entangled condition, or the stage of the second contraction. As segmentation is taking place there is always a violent twisting about each other of the two members of the bivalents, for as soon as the bivalents can be recognized as such, they invariably present the appearance of FIG. 12, save that they are more closely bunched together. Ordinarily they are heaped up in a more compact mass. For the illustration we have selected a nucleus in which a less entangled massing of the bivalents is present (FIG. 12).

That each bivalent, or the majority of them, represents a loop of the spirem, the two sides of which have twisted about each other, and not the two halves of the longitudinally split spirem, is in our opinion beyond question. The longitudinal split of the thread seen in the spirem disappears from sight, and, if it be present during the stages described, the two halves are so closely applied that no trace of the fission can be seen. Almost without exception the two members of each bivalent are twisted about each other, some tightly, others loosely (FIG. 12, 13). In all cases the bivalents, as soon as formed, are massed and entangled into a confused heap.

Later they separate and become irregularly distributed within the nuclear cavity (FIG. 14). At the same time they show a tendency to untwist, and as this is brought about the fact that many represent loops of the spirem is strikingly manifested.

Bonnevie figures the looped and twisted condition of the bivalents, but the manner in which they originate from the spirem is not satisfactorily shown. In fact Bonnevie does not seem to have taken cognizance of the stages which we have described as the rearrangement of the spirem, or the second contraction, and this author has not, in our opinion, shown how her FIG. 33 is derived from FIG. 30. In our opinion her figures not only disprove the very thing she attempts to demonstrate, but lend support to the view set forth in the foregoing paragraphs, namely, that the two members of each bivalent represent pieces of the spirem that were previously arranged end to end and not the longitudinal halves of parts of the spirem.

At the time of cross segmentation of the spirem the chromosomes have attained their largest size.* During the formation of the spindle and later they seem to undergo a condensation by which their size is much reduced. Their number is seven or eight. While seven only were counted in some cases, the writers are inclined to regard eight as the correct haploid number.

FROM SPINDLE TO DAUGHTER NUCLEI

As is so well known, the spindle develops first as a multipolar complex which gradually becomes bipolar. Within the complex of spindle fibers the chromosomes are usually crowded so that the transition from the tightly twisted state of the two members to the large open ring-shaped structure that appears rather constantly in the equatorial plate of the mature spindle, is not readily followed (FIG. 15–17). The ring-shape of the bivalents in the spindle is doubtless the most striking phenomenon in the whole mitotic process of *Allium cernuum*. This form of chromosome is brought about by the fact that the chromosomes are attached to the spindle fibers at a point about midway between the ends. As the two members of each bivalent thus attached are drawn apart by the

* The reader should bear in mind that FIG. 9, 10, 11, 12, 14, 18 and 19 are more highly magnified than FIG. 13, 15, 16, 17, etc.

spindle fibers, each is bent at the place of attachment and a ring results. In FIG. 16 some of the rings are seen from the edge while others have their flat sides turned toward the observer. In many of these rings it is still very evident that they were loops of the spirem as shown above. However, the open or closed ring is not the only form seen in the spindle stage. Sometimes the bivalents appear as two straight or crooked rods attached at or near the ends to the fibers, or X- and Y-shaped forms may appear.

One of the most conspicuous phenomena in the whole mitotic process of this species, and one which is very significant when viewed in the light of the kinetic processes involved in mitosis, is the shape of the chromosomes just before the appearance of the multipolar spindle and at the stage of the mature spindle (Fig. 13, 16, 17). In FIG. 13 the members of each bivalent, or at least the large majority of them, are tightly twisted about each other, while in FIG. 16 and 17 they appear just as uniformly as open rings. The question arises: what kinetic forces are responsible for the twisting in FIG. 13, and what for the condition of FIG. 17? A discussion of this interesting question would extend far beyond the limits of this paper, and we shall merely venture the opinion that neither magnetic nor osmotic activities seem applicable to the phenomena under consideration.

During metakinesis, that is, just at the instant when the segments are separated, each shows its longitudinal fission. Each half-ring, which is made into a U by the pull of the spindle fibers, is now a double U. Frequently just before metakinesis this longitudinal fission can be seen when the free ends of the bivalent are turned directly toward the observer (FIG. 18). In FIG. 19, an anaphase, the double U-like nature of the daughter segments is clearly shown. It may be remarked in passing that the large size and elongated form of the chromosomes of the mature spindle, and the fact that the halves of the U's and V's tend to separate from each other during the anaphase, make counting perplexing and uncertain, in spite of the large size and small number.

The shape and position of the various chromosomes as they pass to the poles seem to speak strongly in favor of a pull being exerted by the spindle fibers, which are in reality fine colloidal

threads and not expressions of osmotic currents. In fact it seems extremely difficult to bring any of these phenomena under explanations based upon osmotic activity.

On arriving at the poles, the chromosomes become closely crowded together in a manner well known for nearly all plants. In the organization of the daughter nuclei, the chromatin does not pass into the finely divided state by the processes of reticulation, alveolization or fragmentation as is characteristic of many gymnosperms and dicots. The various segments do elongate, however, to three or more times their original dimensions, becoming somewhat lumpy or irregular in outline, and finally form a sort of interrupted spirem which is seen as a series of longer or shorter loops or turns passing from the pole to the anti-pole side of the nucleus (FIG. 22). This figure represents a daughter nucleus seen somewhat obliquely from the polar side. The course of the spirem is usually more irregular than in this figure, there being many more short and abrupt genuflections or kinks. We have spoken of this spirem as discontinuous, for the reason that what are regarded as free ends can be found. These free ends are sometimes joined by very delicate threads like the anastomosing threads extending between parallel parts of the spirem in all cells whether purely vegetative or sporogenous. If the apparently free ends were connected by thicker threads, the spirem could then be spoken of as continuous. Whether or not this spirem is continuous or interrupted is of no theoretical importance. The side of each loop, or turn, is wavy or zigzag, due, of course, to the lack of space in the nuclear cavity for the placing of the greatly elongated segments. Whether continuous or interrupted, the whole forms a sort of crown or wreath open both at the pole and anti-pole sides. We assume that the adjacent or parallel sides of the loops are homologous with the sides of the **U**'s or **V**'s that pass to the poles during the previous anaphase. We do not find that the loops or ends of this spirem unite at the polar side to form "Chromatinknoten" either in these nuclei or in somatic cells that are normally preserved. A comparison of a daughter nucleus (FIG. 22) with a granddaughter nucleus (FIG. 23) shows that the arrangement of the chromatin is similar and that it is due to similar causes which may be and probably are purely mechanical.

SUMMARY

The resting nucleus prior to synapsis consists of a reticulum of linin and chromatin granules and of one or more nucleoli. The "Chromatinknoten" of Bonnevie are not present.

Before synapsis there is, as in *Lilium*, a tendency to form a delicate continuous thread or spirem. There is no union of two spirems in synapsis.

Synapsis is a real contraction of the nuclear net and not a growing away of the nuclear membrane from the nuclear network as claimed by Lawson.

The spirem is a direct transformation from the nuclear net.

The hollow spirem is a thick chromatin cord in which a longitudinal split is only occasionally seen and only in parts of the same. This split whenever present always closes up completely before the cross segmentation.

The rearrangement of the spirem takes place which is referable to the *second contraction* described for the lilies and other plants. This results in an entanglement of loops and parallel parts of the spirem which twist upon each other. During this rearrangement the transverse segmentation of the spirem occurs.

Each bivalent chromosome is formed by an approximation, usually side by side, of different lengths of the spirem, which may have appeared as loops or otherwise. Each bivalent is, therefore, to be regarded as two somatic chromosomes that were *previously arranged end to end in the spirem*. The approximation of two somatic chromosomes, side by side, or otherwise, or their adherence end to end to form bivalents, is not known as *synapsis* in botanical literature, nor is it properly called a conjugation.

The prevalent form of bivalent upon the mature spindle is the large ring, although other forms exist.

The daughter segments split longitudinally during metaphase. This fission may be looked upon as a preparation for the second, or homotypic, mitosis.

In the construction of the daughter nuclei, the chromatin does not pass into a finely divided state. The chromatin segments elongate greatly, becoming wavy or zigzag, and form an interrupted spirem by the union of a number of the free ends. This spirem is disposed in the form of a wreath or crown open at both

the polar and antipolar sides. The ends of the chromatin segments do not fuse into "Chromatinknoten" in the daughter nucleus.

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Explanation of plates 23 and 24

All figures were drawn from sections with the aid of the Abbé camera lucida and with Leitz 1/12 immersion and ocular IV or with Zeiss apochromatic immersion 2 mm., apert. 140, and compensating ocular 12. Magnification of figures 3, 4, 9, 10, 11, 12, 14, 18 and 19 about ×2000; all other figures about ×1600.

FIG. 1. Young pollen mother-cell soon after the last somatic division.

FIG. 2. Pollen mother-cell near the close of the period of growth. The nucleus is almost as large as it ever becomes.

FIG. 3. A thin section of a nucleus passing into synapsis; the net-work is forming a thread or spirem.

FIG. 4. A similar stage, showing nearly the whole nucleus. These two figures were near each other in the same section.

FIG. 5. Synapsis is complete.

FIG. 6. The synaptic mass loosening up. The very long, slender thread has shortened into a thick cord.

FIG. 7. The thick, hollow spirem.

FIG. 8. The same stage as FIG. 7. A longitudinal split is seen in two or three places.

FIG. 9. The spirem as it frequently appears before the rearrangement into the second contraction. At this stage the spirem may appear lumpy or with thicker and thinner portions.

FIG. 10, 11. Initial steps of the rearrangement. The chromatin cord is, as a rule, much more entangled than in these figures. Indications of transverse segmentation are seen in FIG. 10.

FIG. 12. Segmentation is about completed. The two members of each bivalent are twisted about each other.

FIG. 13. Similar to the preceding; the twisting is more pronounced in all chromosomes.

FIG. 14. Chromosomes beginning to untwist preparatory to the formation of the spindle.

FIG. 15. Multipolar stage of spindle.

FIG. 16, 17. The fully developed spindle. Nearly all of the chromosomes are rings.

FIG. 18. Spindle showing three chromosomes with the metaphase beginning. At the right a ring-shaped chromosome seen flatwise. In the center the two somewhat curved members of the bivalent are stretched out tangentially upon the spindle. The four free ends seen in these two chromosomes are indications of the longitudinal split. The chromosome at the left is a ring seen from the edge.

FIG. 19. An anaphase; the longitudinal fission of each daughter chromosome is very evident.

FIG. 20. A polar view of an anaphase. The halves of the longitudinally split daughter segments tend to separate.

FIG. 21. A typical anaphase in longitudinal section.

FIG. 22. A polar view of a daughter nucleus showing arrangement of the spirem into a system of loops.

FIG. 23. One cell of a tetrad, or granddaughter cell. The disposition of the chromatin is the same as in the daughter cells at the corresponding stage.

Contributions to the Mesozoic flora of the Atlantic coastal plain—IX. Alabama*

EDWARD W. BERRY

The Tuscaloosa formation as developed in western Alabama has been known for over fifty years to contain remains of fossil plants, and that it contained a large and varied Cretaceous flora has been known since Dr. Eugene A. Smith published a brief list of species in 1894. The principal items in the history of the study of this formation and its flora may be briefly enumerated as follows:

The Tuscaloosa formation was named by Smith and Johnson in 1887 (U. S. Geol. Surv. Bull. 43: 95) from the city and river (now usually known as the Warrior or Black Warrior River) of that name in Alabama. Earlier observers had noticed the presence of sands and clays below the recognized Cretaceous and above the Carboniferous, Professor L. Harper, the state geologist of Mississippi, mentioning them in print as early as 1856 (Proc. Acad. Nat. Sci. Phila. **8**: 126–128) and suggesting that their age is perhaps Permian or possibly Triassic. The same year Prof. Alex. Winchell mentioned the Tuscaloosa mottled clays, calling attention to the contained vegetable remains "appearing like the stems and leaves of dicotyledonous plants." He doubted their Triassic age and in his table of formations they appear in the Lower Cretaceous (Proc. Am. Asso. Adv. Sci. **10**[2]: 92. 1856). Meek and Hayden in discussing (Proc. Acad. Nat. Sci. Phila. **9**: 117–133. 1857) the Alabama Mesozoic mentioned wood and leaves and correlated the lower part with the lowest Cretaceous of New Jersey and Nebraska. Their lithologic characterization clearly indicates that they are discussing the Tuscaloosa, and they say that although the weight of the evidence favors the correlating

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* Published by permission of the Director of the United States Geological Survey. The present paper is a brief abstract of the systematic chapter of a Monograph of the Upper Cretaceous floras of the eastern Gulf Coastal Plain, submitted for publication by the U. S. Geological Survey, this study being a part of the Coastal Plain Investigations directed by T. Wayland Vaughan.

of these beds with the Neocomian of the Old World positive evidence is lacking that a part may not be older than Cretaceous. Subsequently, Professor Hilgard (Geol. and Agr. Miss. 61. 1860) described the beds in Mississippi beneath his Tombigbee sands as the Eutaw group and referred them to the Cretaceous. The following year Meek and Hayden restated their views and definitely correlated the beds in Alabama with the Dakota of the Western Interior (Proc. Acad. Nat. Sci. Phila. **13**: 419–421. 1861).

Again in 1876 Meek (U. S. Geol. Surv. Terr. **9**: 38–42) reaffirms his belief that the basal Cretaceous of Alabama is of the same age as the plastic clays of New Jersey and the Dakota sandstone of the Upper Missouri section.

All of these geologists failed to discriminate the Tuscaloosa from the overlying sands and laminated clays of what is now known as the Eutaw formation. The first reasonably complete account of the Tuscaloosa formation is given by Smith and Johnson in the publication previously alluded to. From the attitude, lithologic character, and stratigraphic position of the beds they correlated the Tuscaloosa with the Potomac of the Middle Atlantic slope, which had just been named and briefly described by McGee (Rep. Health Officer Dist. of Columbia for the year ending June 30, 1885: 19–21, 23–35), a natural correlation since the Potomac as understood in the earlier days of its study included beds which according to the opinions of different students were referred to various levels ranging from the Triassic to the Cretaceous and which subsequent study has shown to constitute a series of well-marked formations, the oldest of Neocomian age and the youngest of Cenomanian age.

From the year 1883 down to the present Dr. Eugene A. Smith, the distinguished state geologist of Alabama, has added to our knowledge of these deposits, being assisted in the earlier years by L. C. Johnson and D. W. Langdon, Jr. The discovery of all of the noteworthy localities for fossil plants is due to their efforts. In 1884 some leaf impressions collected by Langdon in Bibb County were submitted to Leo Lesquereux, among which he recognized a species of *Podozamites* which he thought might indicate a pre-Cretaceous age. Lesquereux afterward determined

a small collection of leaves from the Tuscaloosa beds at Tuscaloosa but this list seems never to have been published.

In 1886 Smith and Langdon discovered several localities for fossil plants in the vicinity of Tuscaloosa (Cottondale, Snows Place, Tuscaloosa) and the next year the United States Geological Survey sent Professor Fontaine into the field.

The latter made large collections of mostly fragmentary material from these outcrops as well as from one or two other outcrops near the town of Tuscaloosa. In 1892 Professor Lester F. Ward visited Alabama and in company with Dr. Smith made extensive collections from Glen Allen and Shirleys Mill. These collections received a preliminary study by Professor Ward, who furnished a list of 35 species which was published by Smith in 1894 in his Report on the Geology of the Coastal Plain of Alabama. This list enumerated the following forms:

Andromeda latifolia Newb. = *Andromeda grandifolia* Berry
Andromeda novae-calcareae Hollick (*Novae-Caesareae*)
Andromeda Parlatorii Heer
Aralia Wellingtoniana Lesq. = *Aralia cottondalensis* Berry
Carpolithus floribundus Newb.
Celastrophyllum crenatum Heer
Celastrophyllum undulatum Newb.
Cinnamomum intermedium Newb. = *Cinnamomum Newberryi* Berry
Cladophlebis parva Font. = *Cladophlebis alabamensis* Berry
Cycadinocarpus circularis Newb.
Czekanowskia capillaris Newb.*
Dewalquea groenlandica Heer*
Diospyros primaeva Heer
Eucalyptus attenuata Newb.*
Eucalyptus nervosa Newb.*
Eucalyptus parvifolia Newb.*
Ficus inaequalis Lesq.
Ficus lanceolato-acuminata Newb.*
Ficus Woolsoni Newb.
Liriodendropsis angustifolia Newb.
Liriodendropsis simplex Newb.
Magnolia alternans Heer*
Magnolia auriculata Newb.
Magnolia glaucoides Newb. = *Magnolia Boulayana* Lesq.
Magnolia longifolia Newb. = *Magnolia Newberryi* Berry
Magnolia speciosa Heer
Myrsine borealis Heer
Populus apiculata Newb. = *Cordia apiculata* Berry
Proteoides daphnogenoides Heer = *Ficus daphnogenoides* Berry
Pterospermites modestus Lesq.*
Tricalycites papyraceus Newb.
Widdringtonites Reichii (Ett.) Heer
Sequoia gracillima (Lesq.) Newb. = *Widdringtonites Reichii* (Ettings.) Heer
Sequoia heterophylla Velenovsky
Sequoia Reichenbachi (Gein.) Heer

In preparation for my work I spent the field season of 1909 in Alabama, revisiting all of the known plant localities and making extensive collections. In company with Dr. L. W. Stephenson the Warrior and Tombigbee river sections were studied by means

* Not recognized by me.

of a launch trip from Tuscaloosa down to the Eocene contact at Moscow; the Coosa and Alabama rivers were traversed from Wetumpka to Montgomery; the Chattahoochee River from Columbus to Gainesville; the upper Tombigbee River in Mississippi and various localities in Tishomingo, Prentiss, and Itawamba counties, Mississippi, were explored. I have also had the benefit of the collections and notes made by Dr. L. W. Stephenson in his extensive field and office studies on the stratigraphy and paleozoology of the Cretaceous of the Eastern Gulf area, as well as the extensive collections previously made for the United States Geological Survey by Smith, Fontaine, and Ward. All of the types and duplicate material are in the collections of the United States National Museum.

Recognizable fossil plants have been found at the following localities in Alabama and a single locality in northeastern Mississippi: near Iuka, Mississippi; Glen Allen, Shirleys Mill, Tuscaloosa, Cottondale, Snow Place, Sanders Ferry Bluff, Whites Bluff, and several other localities in Alabama where only one or two species have been found. The identifiable species other than those new to science are enumerated in the following notes.

LOCALITY NEAR IUKA, MISSISSIPPI

This is the most northerly known plant-bearing outcrop of the Tuscaloosa formation. It is situated in a cut on the Southern Railway $1\frac{5}{8}$ miles east of Iuka in Tishomingo County, and while near the base of the formation in this county it is younger than the plant-bearing Tuscaloosa localities in Alabama.

The following species associated with water worn pellets of amber occur at this outcrop: *Andromeda Wardiana* Lesq., *Andromeda carolinensis* Berry, *Sequoia Reichenbachi* (Gein.) Heer.

LOCALITY NEAR GLEN ALLEN, ALABAMA

This outcrop is in a cut of the St. Louis and San Francisco R. R. about one-quarter of a mile east of Glen Allen near the northern boundary of Fayette County. The following species occur here:

Andromeda grandifolia Berry
Andromeda Novae-Caesareae Hollick
Andromeda Parlatorii Heer
Bauhinia marylandica Berry
Cinnamomum Newberryi Berry
Cissites formosus Heer

Cornophyllum vetustum Newb.
Cycadinocarpus circularis Newb.
Diospyros primaeva Heer
Diospyros rotundifolia Lesq.
Ficus daphnogenoides (Heer) Berry
Ficus Krausiana Heer
Ficus Woolsoni Newb.
Ilex Masoni Lesq.
Liriodendropsis simplex Newb.
Lycopodium cretaceum Berry
Magnolia Lacoeana Lesq.
Magnolia Newberryi Berry
Magnolia speciosa Heer
Marattia cretacea Velenovsky (?)
Myrsine borealis Heer
Myrsine Gaudini (Lesq.) Berry
Pterospermites carolinensis Berry
Salix Lesquereuxii Berry
Tricalycites papyraceus Newb.
Widdringtonites Reichii (Ettings.) Heer
Zizyphus lamarensis Berry

LOCALITY AT SHIRLEYS MILL, ALABAMA

This outcrop is about twenty-five miles south of Glen Allen in southern Fayette County at a point where the old Fayette-Tuscaloosa coach road descends to the Davis Creek bottom. The following species occur at this locality:

Acerates amboyensis Berry
Andromeda grandifolia Berry
Andromeda Novae-Caesareae Hollick
Andromeda Parlatorii Heer
Andromeda Wardiana Lesq.
Asplenium Dicksonianum Heer
Bauhinia cretacea Newb.
Bauhinia marylandica Berry
Brachyphyllum macrocarpum formosum Berry
Carpolithus floribundus Newb.
Celastrophyllum Brittonianum Hollick
Celastrophyllum decurrens Lesq.
Celastrophyllum grandifolium Newb.
Celastrophyllum Newberryanum Hollick
Cinnamomum Newberryi Berry
Citrophyllum aligerum (Lesq.) Berry
Colutea obovata Berry
Crotonophyllum panduraeformis Berry
Dammara borealis Heer
Dermatophyllites acutus Heer
Dewalquea Smithi Berry
Dicksonia groenlandica Heer
Diospyros amboyensis Berry
Diospyros primaeva Heer
Diospyros rotundifolia Lesq.
Ficus daphnogenoides (Heer) Berry
Ficus inaequalis Lesq.
Ficus Krausiana Heer
Ficus Woolsoni Newb.
Geinitzia formosa Heer
Gleichenia delicatula Heer
Inga cretacea Lesq.
Juglans arctica Heer
Kalmia Brittoniana Hollick
Laurophyllum nervillosum Hollick
Laurus plutonia Heer
Leguminosites omphaloboides Lesq.
Liriodendropsis angustifolia Newb.
Liriodendropsis constricta Ward
Liriodendropsis simplex Newb.
Lycopodium cretaceum Berry
Magnolia Boulayana Lesq.
Magnolia Hollicki Berry
Magnolia Lacoeana Lesq.
Magnolia longipes Newb.
Magnolia obtusata Heer
Magnolia speciosa Heer
Malapoenna falcifolia (Lesq.) Knowlton
Myrica emarginata Heer
Myrsine borealis Heer
Nyssa Snowiana Lesq.
Palaeocassia laurinea Lesq.
Panax cretacea Heer
Persoonia Lesquereuxii Knowlton
Phaseolites formus Lesq.
Protodammara speciosa Hollick & Jeffrey
Pterospermites carolinensis Berry
Rhamnus tenax Lesq.
Salix flexuosa Newb.
Salix Lesquereuxii Berry
Salix Meekii Newb.
Sequoia heterophylla Velenovsky
Tricalycites papyraceus Newb.
Widdringtonites Reichii (Ettings.) Heer
Widdringtonites subtilis Heer

LOCALITIES NEAR TUSCALOOSA

The following list embraces species occurring at several outcrops in and near the town of Tuscaloosa in Tuscaloosa County:

Andromeda grandifolia Berry
Andromeda Parlatorii Heer
Diospyros primaeva Heer
Ficus daphnogenoides (Heer) Berry
Ficus Woolsoni Newb.
Magnolia speciosa Heer
Salix flexuosa Newb.
Salix Lesquereuxii Berry

LOCALITY NEAR COTTONDALE

This locality is along the public road about 10 miles east of Tuscaloosa and two miles southeast of the town of Cottondale in Tuscaloosa County. The following species have been identified from this outcrop:

Andromeda Parlatorii Heer
Bauhinia cretacea Newb.
Bauhinia marylandica Berry
Celastrophyllum crenatum Heer
Celastrophyllum grandifolium Newb.
Celastrophyllum undulatum Newb.
Cinnamomum Newberryi Berry
Citrophyllum aligerum (Lesq.) Berry
Cocculus cinnamomeus Velenovsky (?)
Diospyros primaeva Heer
Ficus daphnogenoides (Heer) Berry
Ficus inaequalis Lesq.
Ficus Krausiana Heer
Ficus Woolsoni Newb.
Geinitzia formosa Heer
Ilex Masoni Lesq.
Juglans arctica Heer
Laurus plutonia Heer
Liriodendron Meekii Heer
Magnolia Capellinii Heer
Magnolia longipes Newb.
Magnolia speciosa Heer
Malapoenna cretacea (Lesq.) Knowlton
Myrica emarginata Heer
Myrsine Gaudini (Lesq.) Berry
Persea valida Hollick
Phaseolites formus Lesq.
Pinus raritanensis Berry
Platanus latior (Lesq.) Knowlton
Populus hyperborea Heer
Protophyllocladus subintegrifolius (Lesq.) Berry
Pterospermites carolinensis Berry
Salix Lesquereuxii Berry
Sassafras acutilobum Lesq.
Sequoia Reichenbachi (Gein.) Heer

LOCALITY ON SNOW PLANTATION

Two plant-bearing outcrops occur on the Snow Plantation about nine miles southwest of Tuscaloosa. These are known in the literature as "Upper Ravine" and "Big Gully, Snow Place" and are in enormous gullies eroded into the upland from the west bank of the Warrior River. The following species occur here:

Abietites foliosus (Font.) Berry
Andromeda grandifolia Berry
Andromeda Novae-Caesareae Hollick
Andromeda Parlatorii Heer
Celastrophyllum carolinense Berry
Celastrophyllum crenatum Heer
Dammara borealis Heer
Dicksonia groenlandica Heer
Dryopterites Stephensoni Berry
Eucalyptus Geinitzi Heer
Eucalyptus latifolia Hollick
Ficus crassipes Heer

Ficus daphnogenoides (Heer) Berry
Ficus Krausiana Heer
Laurophyllum angustifolium Newb. (?)
Myrica emarginata Heer
Myrsine borealis Heer
Podozamites marginatus Heer
Salix flexuosa Newb.
Salix Lesquereuxii Berry
Sequoia ambigua Heer
Sequoia fastigiata (Sternb.) Heer
Sequoia Reichenbachi (Gein.) Heer
Tricalycites papyraceus Newb.
Widdringtonites Reichii (Ettings.) Heer
Widdringtonites subtilis Heer

SANDERS FERRY BLUFF

This locality is on the west bank of the Warrior River about eleven miles southwest of Tuscaloosa in the county of that name. The following plants occur at this outcrop:

Acerates amboyensis Berry
Ficus crassipes Heer
Ficus Krausiana Heer
Salix flexuosa Newb.
Salix Lesquereuxii Berry

WHITES BLUFF OUTCROP

This locality is on the right bank of the Warrior River in northeastern Green County, three hundred and nine miles above Mobile and near the top of the Tuscaloosa formation. The following species have been identified from this outcrop:

Brachyphyllum macrocarpum formosum Berry
Dewalquea Smithi Berry
Sequoia heterophylla Velenovsky
Sequoia Reichenbachi (Gein.) Heer
Widdringtonites Reichii (Ettings.) Heer

In addition to the well-known Cretaceous species in the foregoing lists the Tuscaloosa formation has yielded upwards of fifty new species which are described in the following genera: *Aralia, Calycites, Capparites* (2), *Carpolithus, Cassia, Celastrophyllum* (5), *Cladophlebis, Cocculus* (2), *Conocarpites, Eorhamnidium, Equisetum, Eugenia, Ficus* (3), *Grewiopsis* (2), *Hymenaea, Jungermannites, Leguminosites* (3), *Lycopodites, Malapoenna, Menispermites* (2), *Myrica, Oreodaphne, Persoonia, Phyllites* (2), *Piperites, Platanus* (2), *Populites, Proteoides, Sapindus, Sapotacites* (3), and *Sphaerites*.

The flora as a whole comprises over 150 species, of which over 40 per cent. of the genera are not represented in the existing flora. None of the species survive into the lower Eocene.

Eighty-seven genera segregated into 48 families in 31 orders are represented, the most abundant orders being the Ranales with 15 species, the Coniferales with 14 and the Urticales with 8. The largest single genus is *Celastrophyllum* with 12 species. The

Dicotyledonae of the Tuscaloosa formation number 123 species, distributed in 34 families in 21 orders. The Choripetalae number 107, the Gamopetalae but 16 forms.

The flora as a whole is a lowland coastal flora, many of the species being strand types. It indicates a land surface of rather uniform topography, an abundant and well-distributed rainfall, equable temperatures of warm temperate or subtropical type, with slight seasonal changes.

Meager floras are found also in the younger Cretaceous strata of the Eutaw and Ripley formations, but these are not included in the present contribution.

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A bibliography of works on meiosis and somatic mitosis in the Angiosperms

MAURICE PICARD

The accompanying bibliography was prepared, in the first instance, for the compiler's personal use. He publishes it, believing that there is need of such a means of reference to the works on meiosis and somatic mitosis in the plants already studied, and that, by such publication, interest may be aroused in the groups hitherto neglected. As far as the writer knows, there is no such bibliography in existence at the present time, nor has the plan of citing literature on mitosis with reference to the systematic position of the plants studied ever been adopted. Inasmuch as the object of the bibliography is to provide a working basis for further research no attempt has been made to make the citations on the individual plants exhaustive. It is believed, however, that from the citations given one can obtain references to all the literature. Works published before 1880 have not been cited; the citations extend to May, 1913. Works on the morphological development of the male and female gametophytes have been mentioned only when they contain matter of cytological interest. The writer has used his own discretion with respect to articles of questionable relevance, and also in deciding whether or not incidental references to somatic mitosis should be cited.

The bibliography was compiled chiefly at the libraries of Cornell University, Columbia University, and the New York Botanical Garden; and my thanks are due to their librarians for courtesies shown me. I am also obliged to Professor G. F. Atkinson, Professor R. A. Harper, and Dr. A. B. Stout for access to some otherwise unobtainable articles, and to Professor G. F. Atkinson for examining the manuscript sheets.

The writer is aware that such a bibliography as here presented must be inadequate in many ways, and he hopes that those who can will acquaint him with omitted references.

The nomenclature employed is that of N. L. Britton's "Manual

of the Flora of the Northern States and Canada," 2d ed., 1907, when the plants cited are contained in this volume. In the case of forms not within the range of this work, the nomenclature follows the rules laid down by the International Botanical Congress at Vienna. Where the two systems differ, the designation of the Vienna code is added in parentheses.

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Arisaema triphyllum **Atkinson, G. F. '99**, Bot. Gaz. **28**: 1–26.

Peltandra undulata (*virginica*), *Symplocarpus foetidus* **Duggar, B. M. '00,** Bot. Gaz. **29**: 81–98.

Arum maculatum **Rosenberg, O. '05,** Bot. Not. **1905**: 1–24.

Richardia africana **Overton, J. B. '09**, Ann. Bot. **23**: 19–61.

XYRIDALES—COMMELINACEAE

Tradescantia virginiana **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

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LILIALES—MELANTHACEAE

Abama ossifraga (*Narthecium ossifragum*) **Berghs, J. '05,** La Cellule **22**: 139–160.

Grégoire, V. '05, La Cellule **22**: 221–276.

LILIACEAE

Hemerocallis fulva **Tangl, E. '82,** Denkschr. Kais. Akad. Wiss. Wien, **45**: 67–86.

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Allium

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Fritillaria

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Hyacinthus orientalis

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Berghs, J. '05, La Cellule **22**: 201–214.
Grégoire, V. '06, La Cellule **23**: 309–358.

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Nothoscordum fragrans

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Funkia

Strasburger, E. '82, Arch. Mikr. Anat. **21**: 476–589.
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Strasburger, E. '05, Jahrb. Wiss. Bot. **42**: 1–71.
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Galtonia candicans

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Yucca

Körnicke, M. '01, Sitzungsber. Niederrhein. Ges. Natur- und Heilkunde Bonn. **4**, III.
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Bonnet, J. '12, Arch. Zellforsch. **7**: 231–241.

CONVALLARIACEAE

Asparagus officinalis — **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.

Salomonia biflora, (*Polygonatum biflorum*) — **Cardiff, I. D. '06,** Bull. Torrey Club **33**: 271–306.

Convallaria — **Strasburger, E. '84**, Neue Untersuchungen über den Befructungsvorgang bei den Phanerogamen, etc. Jena.
Wiegand, K. '99, Bot. Gaz. **28**: 328–359.
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Schniewind-Thies, J. '01, Die Reduktion, etc. Jena.
Berghs, J. '05, La Cellule **22**: 41–54.

Vagnera (*Smilacina*) — **Lawson, A. A. '11,** Trans. Roy. Soc. Edin. **47**: 591–604.

Trillium — **Atkinson, G. F. '99,** Bot. Gaz. **28**: 1–26.
Ernst, A. '02, Flora **91**: 1–46.
Grégoire, V., & Wygaerts, A. '04, La Cellule **21**: 5–76.

AMARYLLIDACEAE

Alstroemeria — **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.
Guignard, L. '84, Ann. Sci. Nat. Bot. VI. **17**: 5–59.

Galanthus nivalis — **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.
Guignard, L. '91, Ann. Sci. Nat. Bot. VII. **14**: 163–296.

Leucojum — **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.
Went, F. '87, Ber. Deuts. Bot. Ges. **5**: 247–258.
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Guignard, L. '91, Ann. Sci. Nat. Bot. VII. **14**: 163–296.
Strasburger, E. '95, Jahrb. Wiss. Bot. **28**: 151–204.
Strasburger, E. '00, Über Reduktionsteilung, etc. Hist. Beitr. **6**. Jena.

Narcissus **Went, F. '87,** Ber. Deuts. Bot. Ges. **5**: 247–258.

IRIDACEAE

Iris **Strasburger, E. '82**, Arch. Mikr. Anat. **21**: 476–589.

Strasburger, E. '95, Jahrb. Wiss. Bot. **28**: 151–204.

Strasburger, E. '00, Über Reduktionsteilung, etc. Hist. Beitr. **6.** Jena.

Körnicke, M. '01, Sitzungsber. Niederrhein. Ges. Natur- und Heilkunde Bonn. **4**, III.

Strasburger, E. '05, Jahrb. Wiss. Bot. **42**: 1–71.

Miyake, K. '05, Jahrb. Wiss. Bot. **42**: 83–120.

Gladiolus hybrid **Metcalf, H. '01,** Proc. Nebraska Acad. Sci. **7**: 109.

ORCHIDALES—ORCHIDACEAE

Listera **Guignard, L. '84,** Ann. Sci. Nat. Bot. VI. **17**: 5–59.

Guignard, L. '85, Ann. Sci. Nat. Bot. VI. **20**: 310–372.

Guignard, L. '91, Ann. Sci. Nat. Bot. VII. **14**: 163–296.

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Orchis **Guignard, L. '82,** Ann. Sci. Nat. Bot. VI. **14**: 26–45.

Strasburger, E. '95, Jahrb. Wiss. Bot. **28**: 151–204.

Limodorum abortivum **Guignard, L. '97,** Ann. Sci. Nat. Bot. VIII. **6**: 177–220.

SCITAMINALES—MUSACEAE

Musa **Tischler, G. '10,** Arch. Zellforsch. **5**: 622–670.

CANNACEAE

Canna indica **Wiegand, K. '00,** Bot. Gaz. **30**: 25–47.

Körnicke, M. '01, Sitzungsber. Niederrhein. Ges. Natur- und Heilkunde Bonn. **4**, III.

ANGIOSPERMAE—DICOTYLEDONES

CASUARINALES—CASUARINACEAE

Casuarina **Juel, H. O. '03,** Flora **92**: 284–293.

URTICALES—MORACEAE (URTICACEAE)

Morus indica **Tahara, M. '09,** Bot. Mag. Tokyo, **23**: 343–353.

Tahara, M. '10, Bot. Mag. Tokyo, **24**: 281–298.

Cannabis sativa **Strasburger, E. '10,** Jahrb. Wiss. Bot. **48**: 428–520.

URTICACEAE

Urtica dioica, Elatostema **Strasburger, E. '10,** Jahrb. Wiss. Bot. **47**: 245–288.

SANTALALES—LORANTHACEAE

Viscum album **Guignard, L. '85,** Ann. Sci. Nat. Bot. VI. **20**: 310–372.

POLYGONALES—POLYGONACEAE

Rumex Patientia, Rheum undulatum **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

Fagopyrum esculentum **Stevens, N. E. '12,** Bot. Gaz. **53**: 277–308.

CHENOPODIALES—NYCTAGINACEAE

Mirabilis hybrid **Tischler, G. '08,** Arch. Zellforsch. **1**: 33–151.

PORTULACACEAE

Claytonia virginica **Cardiff, I. D. '06,** Bull. Torrey Club **33**: 271–306.

CHENOPODIACEAE

Beta **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

CARYOPHYLLACEAE

Melandrium rubrum **Strasburger, E. '10,** Jahrb. Wiss. Bot. **48**: 427–520.

RANALES—NYMPHAEACEAE

Nymphaea alba, Nuphar luteum (Nymphaea lutea) **Guignard, L. '97,** Ann. Sci. Nat. Bot. VIII. **6**: 177–220.

Lubimenko, W., & Maige, A. '07, Rév. Gén. Bot. **19**: 404–425; 433–458; 474–505.

Nymphaea alba **Strasburger, E. '00,** Über Reduktionsteilung. etc. Hist. Beitr. **6**. Jena.

RANUNCULACEAE

Clematis recta **Guignard, L. '85,** Ann. Sci. Nat. Bot. VI. **20**: 310–372.

Trollius europaeus **Lundegårdh, H. '09,** Sv. Bot. Tidskr. **3**: 78–124.

Helleborus foetidus **Strasburger, E. '88,** Über Kern- und Zellteilung, etc. Hist. Beitr. **1**. Jena.

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Thalictrum purpurascens **Overton, J. B. '09,** Ann. Bot. **23**: 19–61.
Aconitum Napellus **Overton, J. B. '05,** Jahrb. Wiss. Bot. **42**: 121–153.
Paeonia spectabilis **Overton, J. B. '93,** Vierteljahr. Naturf. Ges. Zürich **38.**

MAGNOLIACEAE

Magnolia **Guignard, L. '97**, Ann. Sci. Nat. Bot. VIII. **6**: 177–220.
Magnolia, Liriodendron **Andrews, F. M. '02,** Beih. Bot. Centralbl. **11**: 134–142.

BERBERIDACEAE

Podophyllum peltatum **Mottier, D. M. '97,** Jahrb. Wiss. Bot. **30**: 169–204.
Strasburger, E. '00, Über Reduktionsteilung, etc. Hist. Beitr. **6.** Jena.
Körnicke, M. '01, Sitzungsber. Niederrhein. Ges. Natur- und Heilkunde **4**, III.
Mottier, D. M. '03, Bot. Gaz. **35**: 250–282.
Mottier, D. M. '05, Bot. Gaz. **40**: 171–177.
Overton, J. B. '05, Jahrb. Wiss. Bot. **42**: 121–153.
Mottier, D. M. '07, Ann. Bot. **21**: 309–347.

CALYCANTHACEAE

Calycanthus floridus **Overton, J. B. '05,** Jahrb. Wiss. Bot. **42**: 121–153.
Overton, J. B. '09, Ann. Bot. **23**: 19–61.

CERATOPHYLLACEAE

Ceratophyllum submersum **Strasburger, E. '02,** Jahrb. Wiss. Bot. **37**: 477–526.

PAPAVERALES—PAPAVERACEAE

Corydalis cava **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.

CRUCIFERAE

Hesperis matronalis **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

Bursa (Capsella), Sisymbrium, Brassica, Stenophragma, Alyssum, Iberis, Lunaria — **Laibach, I. '07,** Beih. Bot. Centralbl. **22**: 191–210.

Bursa (Capsella), [*Zostera* and *Calendula* briefly, also] — **Rosenberg, O. '08,** Flora **93**: 251–259.

SARRACENIALES—DROSERACEAE

Drosera — **Rosenberg, O. '99,** Meddel. Hög. Bot. Inst. Stock. 2^{11}: 1–126; **'01**, 4^{11}: 1–21.

Rosenberg, O. '03, Ber. Deuts. Bot. Ges. **21**: 110–119.

Rosenberg, O. '04, Meddel. Hög. Bot. Inst. Stock. 6^{10}: 1–13.

Rosenberg, O. '04, Ber. Deuts. Bot. Ges. **22**: 47–53.

Berghs, J. '05, La Cellule **22**: 139–160.

Rosenberg, O. '06, Kjellman Bot. Stud. 237–243.

Rosenberg, O. '09, Köngl. Sv. Vet.-Akad. Handl. **43**: 3–63.

Rosenberg, O. '09, Sv. Bot. Tidskr. **3**: 163.

ROSALES—PAPILIONACEAE (LEGUMINOSAE)

Laburnum — **Strasburger, E. '07,** Jahrb. Wiss. Bot. **44**: 482–555.

Lathyrus odoratus — **Gregory, R. P. '05,** Proc. Cam. Phil. Soc. **13**: 148–157.

Phaseolus — **Zimmermann, A. '96,** Morph. und Physiol. pfl. Zellkernes. Jena.

Wager, H. '04, Ann. Bot. **18**: 29–55.

Mano, T. Martins '05, La Cellule **22**: 55–78.

Pisum — **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

Cannon, W. A. '03, Bull. Torrey Club **30**: 519–543.

Strasburger, E. '07, Jahrb. Wiss. Bot. **44**: 482–555.

Strasburger, E. '11, Flora **102**: 1–23.

Vicia Faba — **Zimmermann, A. '96,** Morph. und Physiol. pfl. Zellkernes. Jena.

Strasburger, E. '00, Über Reduktionsteilung, etc. Hist. Beitr. **6**. Jena.

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Gardner, B. '01, Contr. Bot. Lab. Univ. Pa. **2**: 150–182.
Karpoff, W. '04, Unters. aus Mosk. Landwirt. Inst. **1**.
Karpoff, W. '04, Trav. Inst. Agron. Moscou.
Lundegårdh, H. '10, Sv. Bot. Tidskr. **4**: 174–196.
Lundegårdh, H. '10, Jahrb. Wiss. Bot. **48**: 285–378.
Fraser, H., & Snell, J. '11, Ann. Bot. **25**: 845–855.
Lundegårdh, H. '12, Jahrb. Wiss. Bot. **51**: 226–280.

GROSSULARIACEAE (SAXIFRAGACEAE)

Ribes hybrids — **Tischler, G. '06,** Jahrb. Wiss. Bot. **42**: 545–578.

ROSACEAE

Rosa, Rubus, Alchemilla — **Strasburger, E. '04,** Jahrb. Wiss. Bot. **41**: 88–164.

Rosa — **Rosenberg, O. '09,** Sv. Bot. Tisdkr. **3**: 150–162.

Fragaria elatior — **Strasburger, E. '09,** Zeitpunkt Best., etc. Hist. Beitr. **7**. Jena.

Potentilla hybrid — **Tischler, G. '08,** Arch. Zellforsch. **1**: 33–151.

GERANIALES—TROPAEOLACEAE

Tropaeolum majus — **Strasburger, E. '80,** Zellbildung und Zellteilung. Jena.

RUTACEAE

Dictamnus albus — **Strasburger, E. '82,** Arch. Mikr. Anat. **21**: 476–589.
Strasburger, E. '88, Über Kern- und Zellteilung, etc. Hist. Beitr. **1**. Jena.

Citrus — **Strasburger, E. '07,** Jahrb. Wiss. Bot. **44**: 482–555.
Osawa, '12, Jour. Coll. Agr. Imp. Univ. Tokyo, **4**: 83–116.

EUPHORBIACEAE

Mercurialis annua — **Strasburger, E. '10,** Jahrb. Wiss. Bot. **48**: 428–520.

Malte, M. O. '10, Embryologiska och cytologiska undersökningar öfver *Mercurialis annua.* Diss. Lund.

SAPINDALES—ACERACEAE

Acer

Cardiff, I. D. '06, Bull. Torrey Club **33**: 271–306.

Darling, C. A. '09, Bull. Torrey Club **36**: 177–199.

Darling, C. A. '12, Bull. Torrey Club **39**: 407–410.

MALVALES—MALVACEAE

Gossypium hybrid

Cannon, W. A. '03, Bull. Torrey Club **30**: 133–172.

Balls, W. L. '10, Ann. Bot. **24**: 653–665.

Lavatera

Byxbee, E. S. '00, Proc. Calif. Acad. Sci. III. **2**: 63–82.

PARIETALES—PASSIFLORACEAE

Passiflora caerulea

Williams, C. L. '99, Proc. Calif. Acad. Sci. III. **1**: 189–206.

THYMELEALES—THYMELEACEAE

Daphne, Gnidia, Wickstroemia indica

Strasburger, E. '09, Zeitpunkt Best., etc. Hist. Beitr. **7.** Jena.

MYRTALES—ONAGRACEAE

Onagra (*Oenothera*) and *Oenothera*

Gates, R. R. '07, Bot. Gaz. **43**: 81–115.

Geerts, J. M. '07, Ber. Deuts. Bot. Ges. **25**: 191–195.

Lutz, A. M. '07, Science, II. **26**: 151–152.

Gates, R. R. '08, Bot. Gaz. **46**: 1–34.

Geerts, J. M. '08, Ber. Deuts. Bot. Ges. **26**: 608–614.

Geerts, J. M. '09, Réceuil Trav. Bot. Néerlandais **5**: 93–209.

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CORNELL UNIVERSITY, ITHACA.

INDEX TO AMERICAN BOTANICAL LITERATURE
(1910–1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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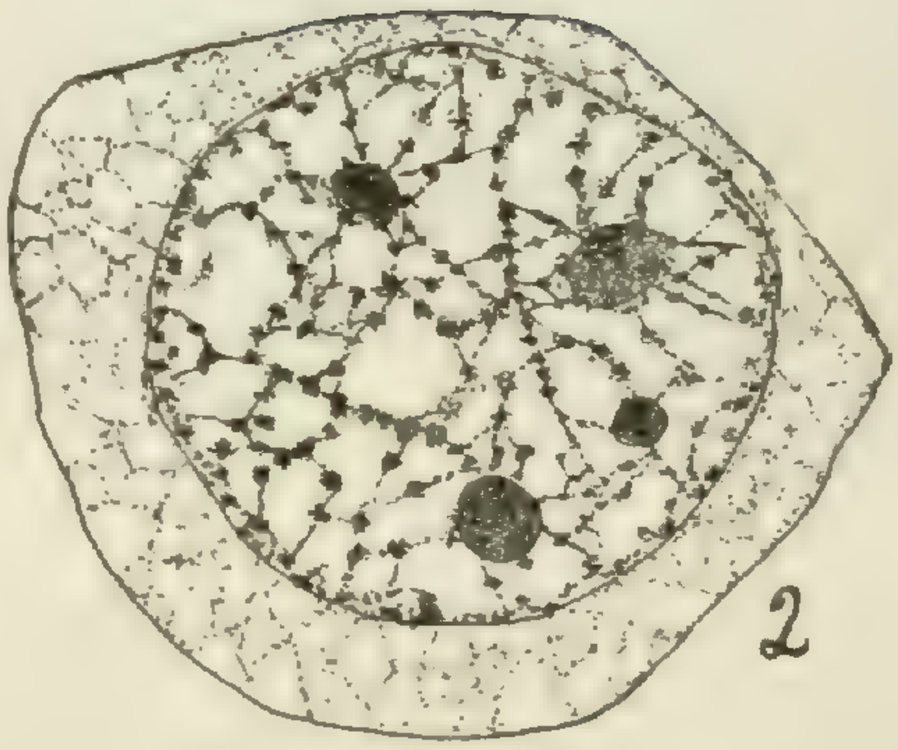
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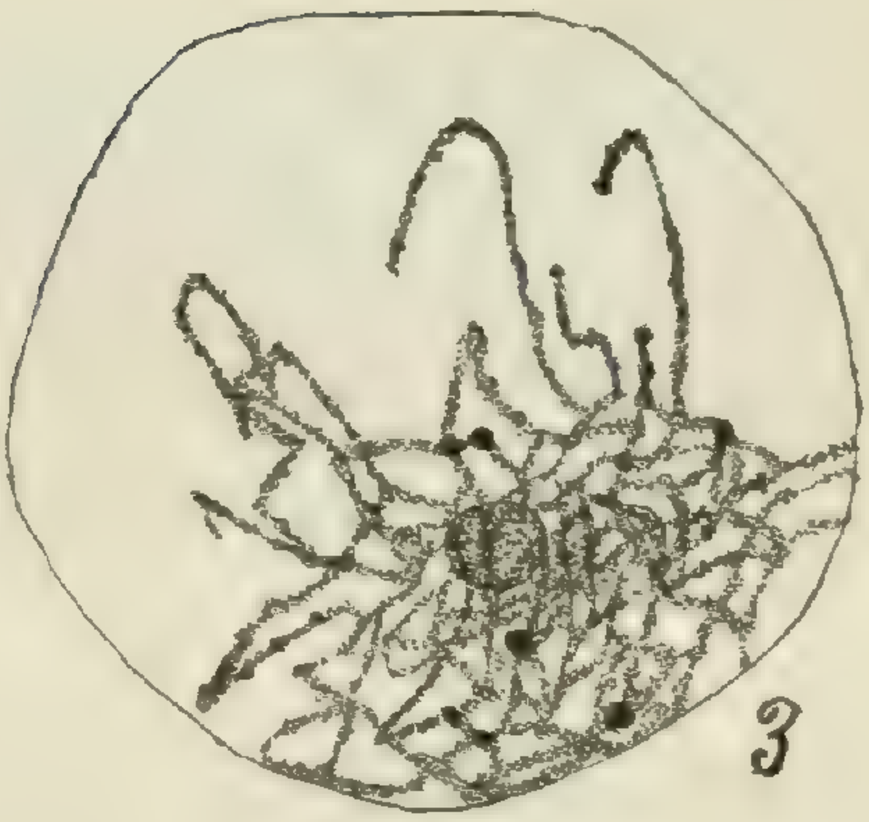
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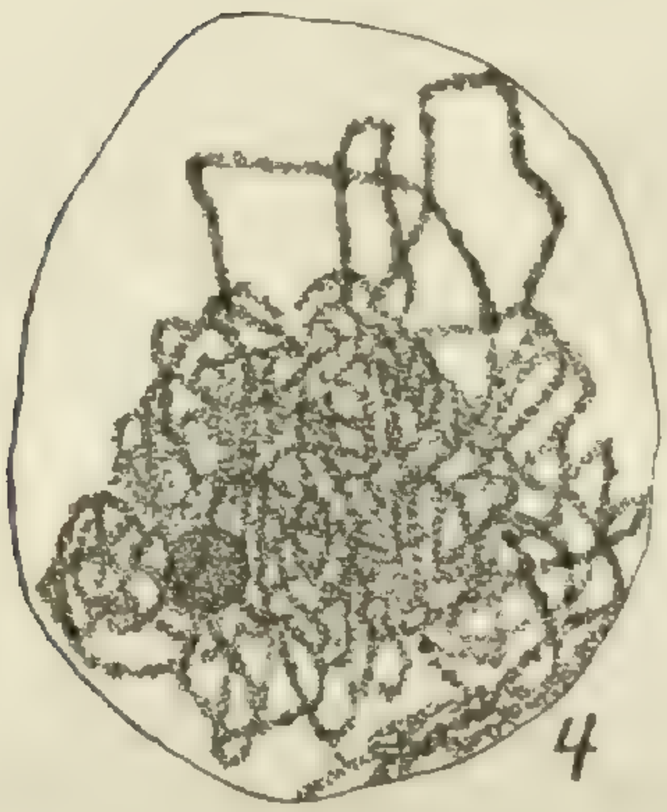
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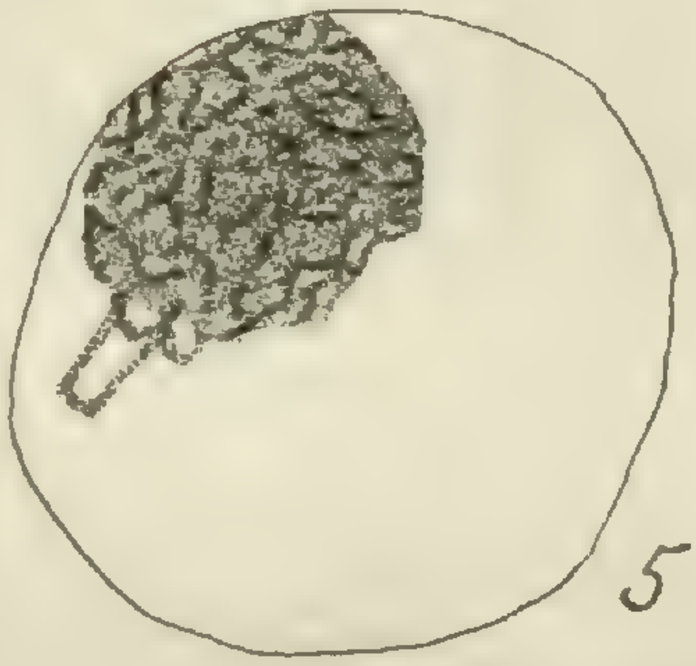
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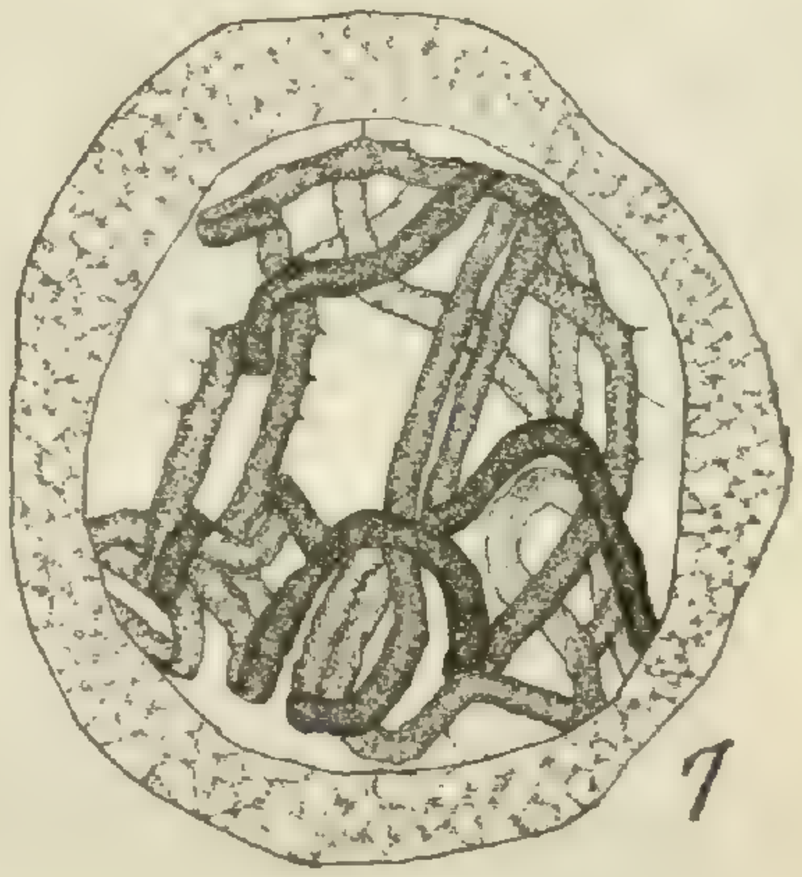
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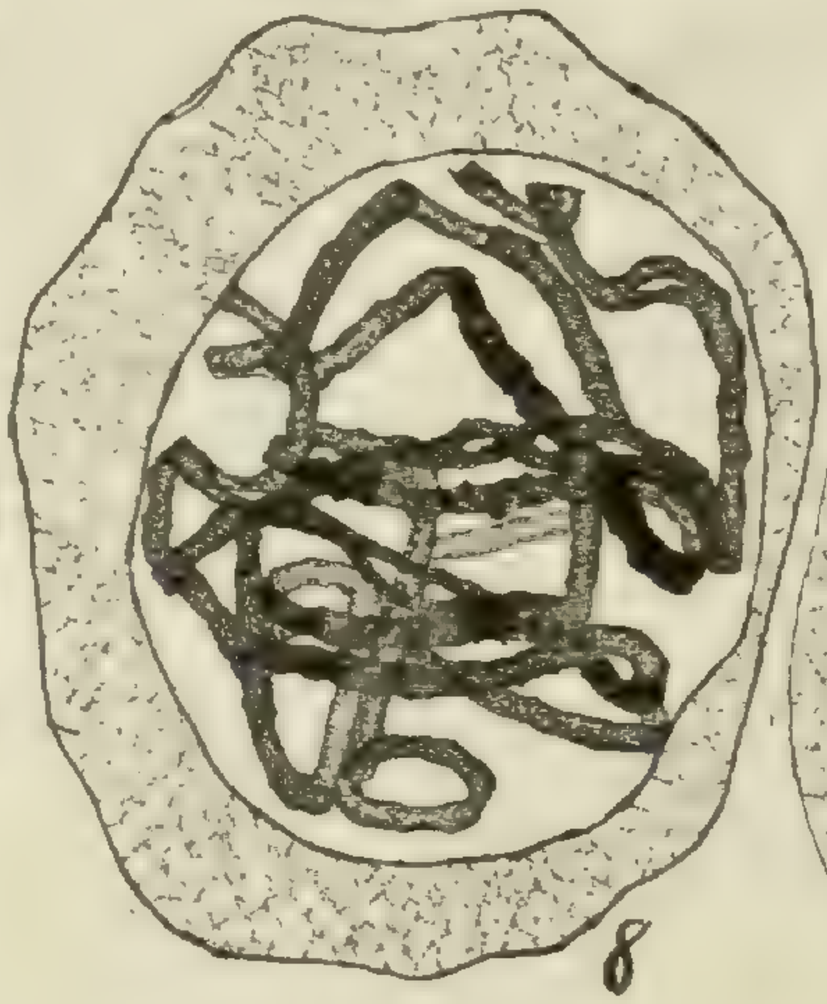
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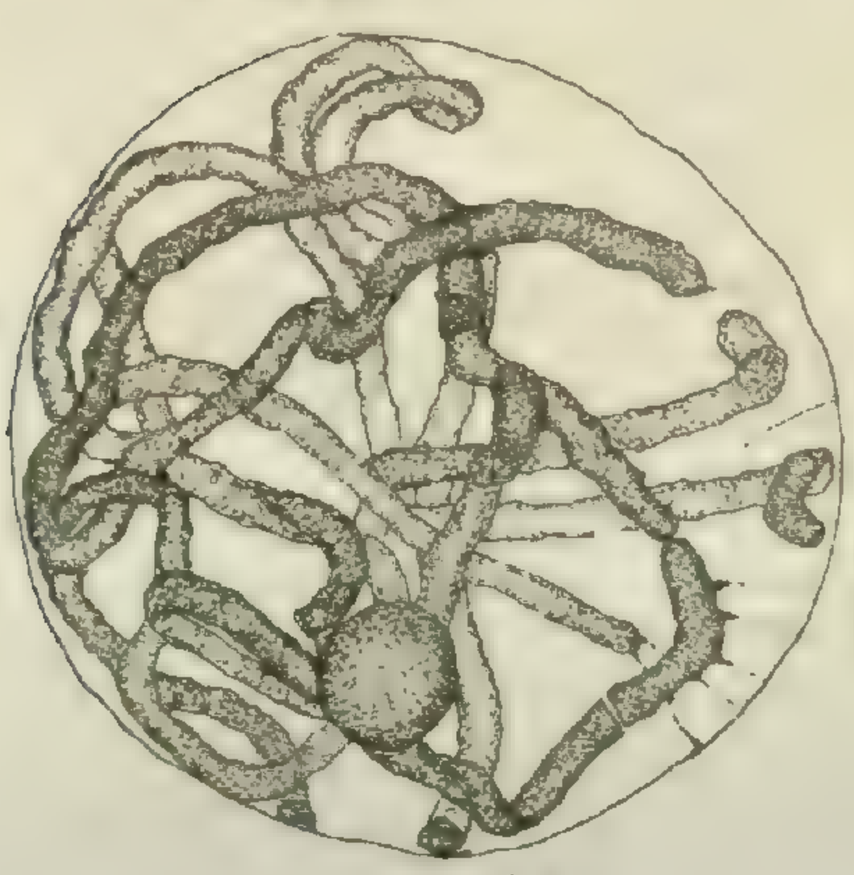
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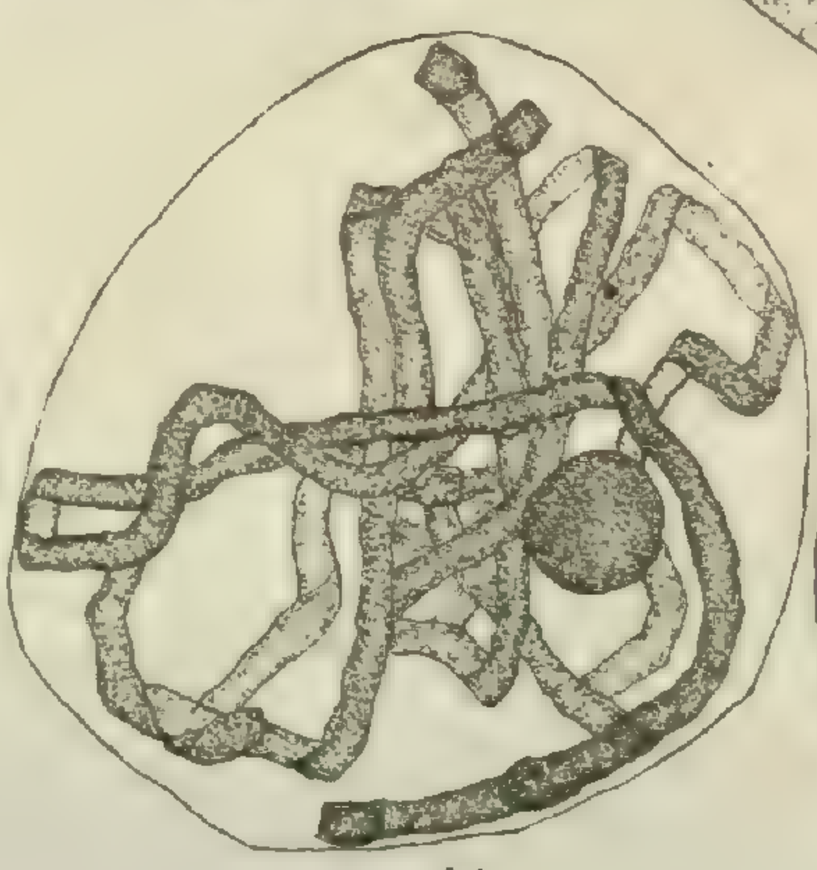
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MOTTIER AND NOTHNAGEL: CHROMOSOMES OF ALLIUM CERNUUM

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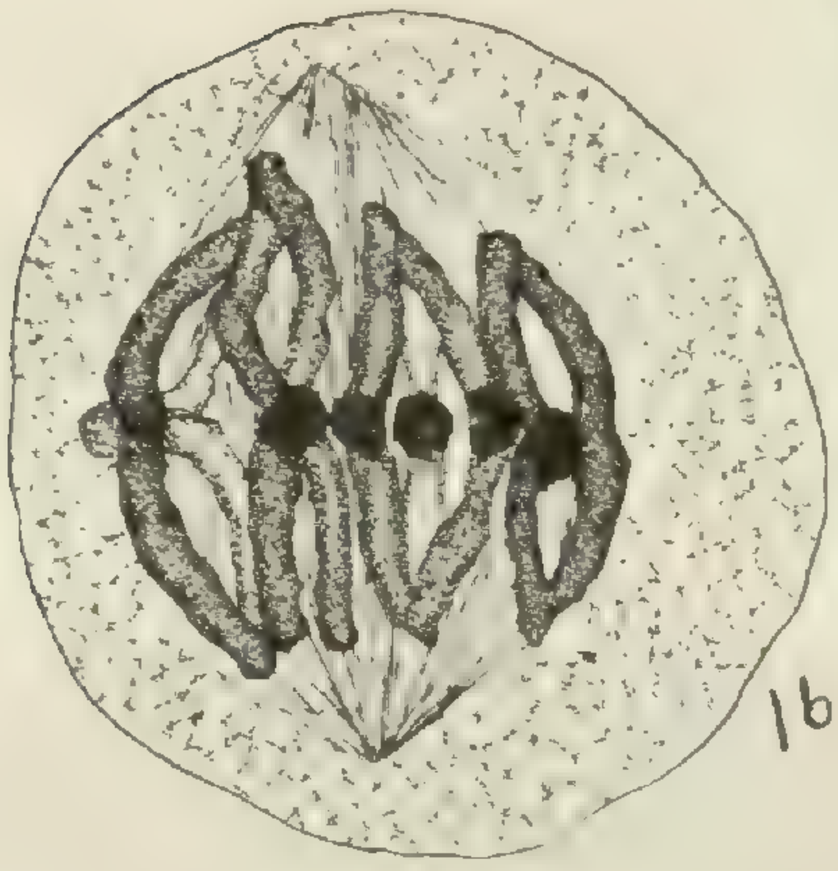
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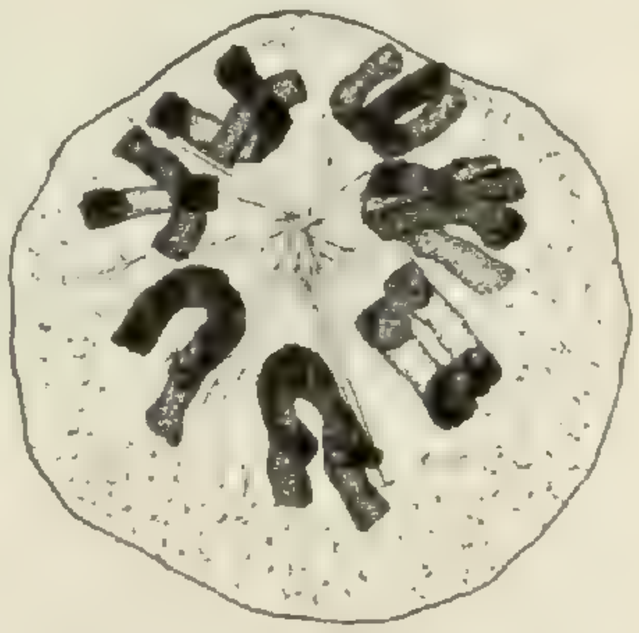
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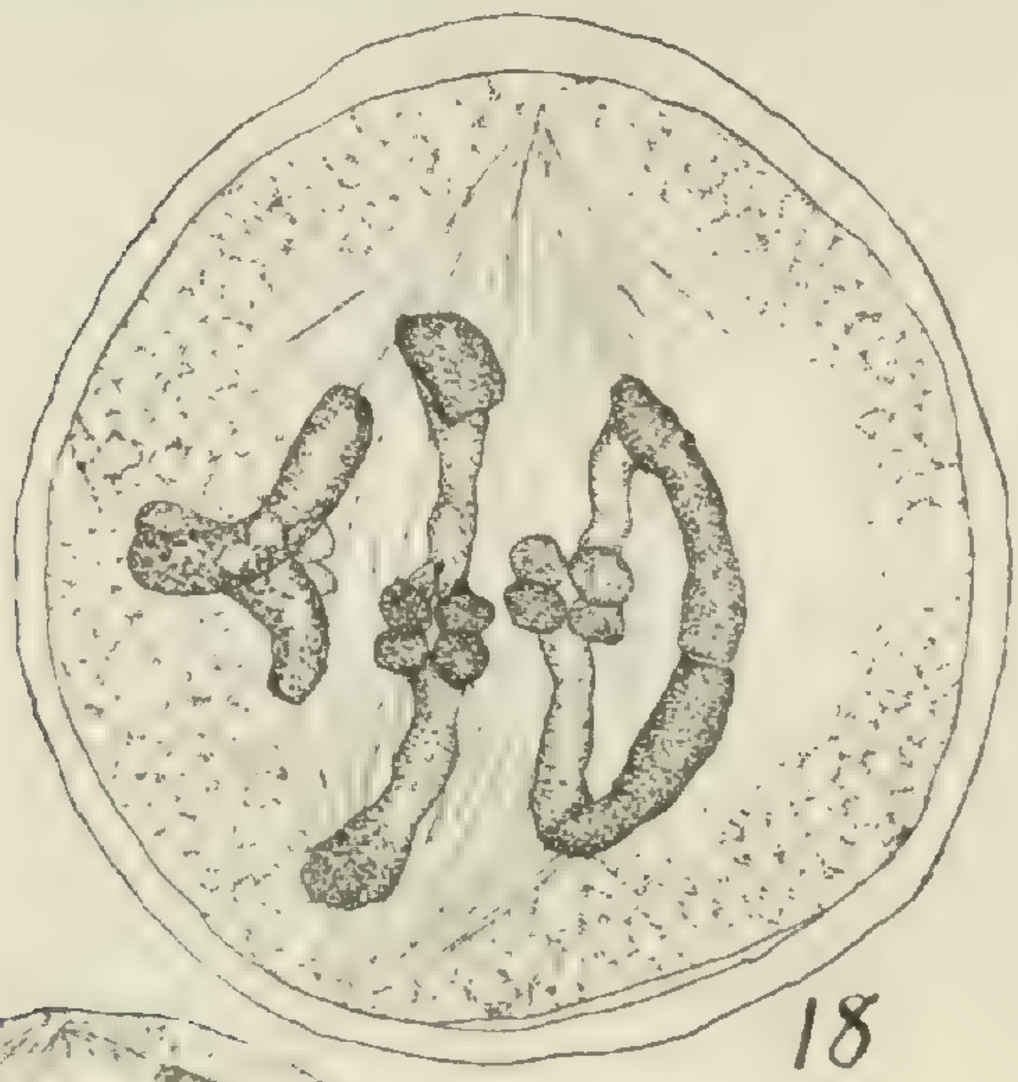
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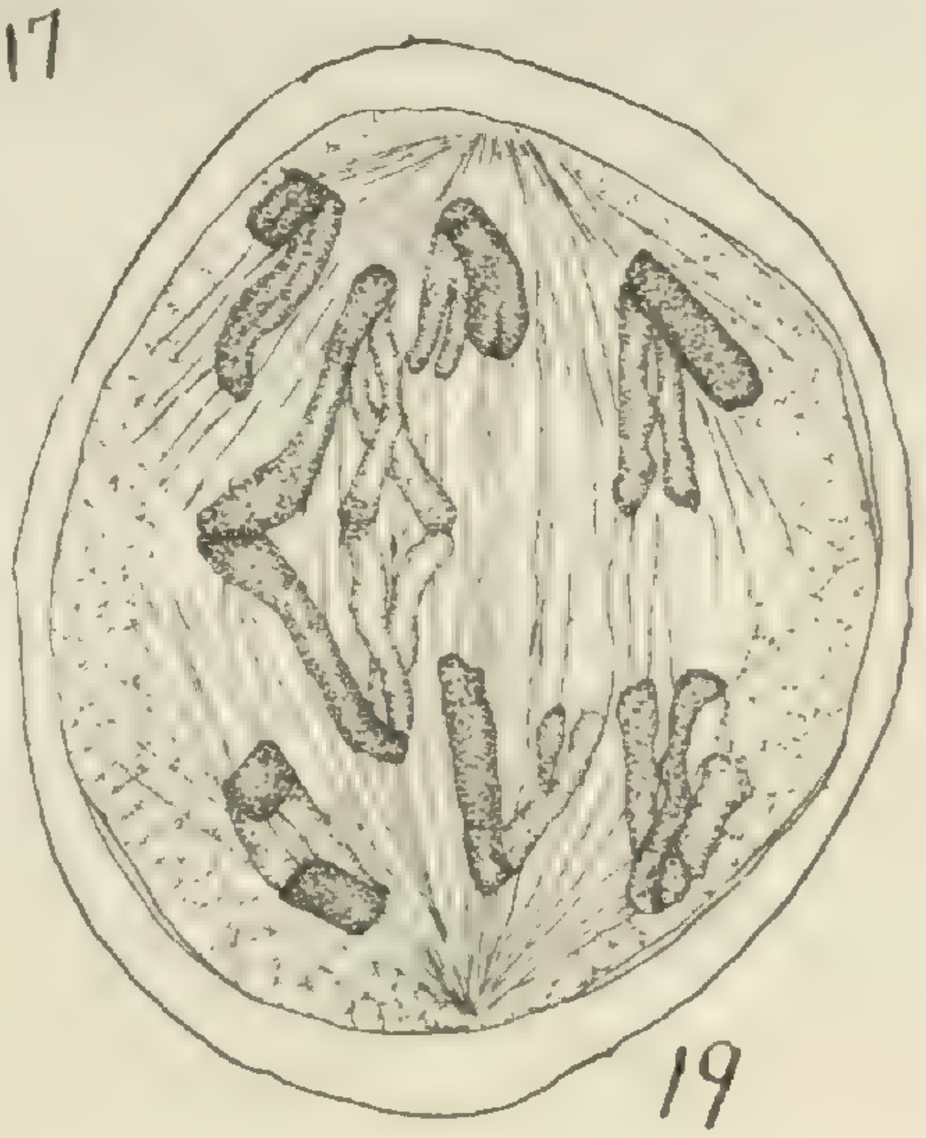
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MOTTIER AND NOTHNAGEL: CHROMOSOMES OF ALLIUM CERNUUM

E. L. Morris.

Vol. 40 No. 11

BULLETIN

OF THE

TORREY BOTANICAL CLUB

NOVEMBER, 1913

Edward Lyman Morris

EDWARD B. CHAMBERLAIN

(WITH PORTRAIT)

The sudden death of Edward L. Morris on September 14, last, is a loss not easy to estimate. He was by preference a student of systematic botany, but long experience as a successful teacher, and active work as a museum curator, gave him a breadth of scientific training and an appreciation of popular and scientific points of view that are not often combined in those whose position makes them the interpreters of science to the public.

Those who knew Mr. Morris feel that their personal loss overshadows everything else. He had to an unusual degree the genial charm of manner that makes and retains friends, and a loyalty that takes no account of time or effort spent in helpful service. His daily life was so full of patience, cheerfulness, and sympathy, that few realized how great, at times, was his own burden. Even when his own life was full of trouble, he was never without the characteristic cordial greeting for everyone he met. With high ideals and the strong convictions that accompany them, he was frank in the expression of opinion, but at the same time modest in statement and considerate of the views of those from whom he differed. The affectionate respect of his associates and the coöperation they gave him are striking testimonials to his own personality.

In his own work Mr. Morris set for himself a severe standard, and demanded like faithfulness from others; yet he worked with

[The BULLETIN for October (**40**: 529–598. *pl. 23, 24*) was issued 15 O 1913.]

an enthusiasm that enlivened dry detail and routine. Whatever he did showed painstaking method, sincerity of purpose, and devotion. As a colleague has written of him, "He put his heart as well as his conscience into his work." He was a patient investigator and a close observer, but willing to defer any conclusion until he had a first-hand knowledge of the facts. This desire for truthfulness made him chary of publication; there was so often some minor point that required more study for a complete understanding of the case.

The facts of Mr. Morris's life are, briefly, as follows:—He was born at Monson, Mass., October 23, 1870, the son of Edward Franklin Morris and Louise Janette Clapp, and his youth was spent in the vicinity of his birthplace. At as early an age as eleven, he began the systematic study and collection of the plants of the township, continuing his collecting throughout his preparatory school course. Entering Amherst College in the autumn of 1888 from Monson Academy, he was given special credit for the botanical work already done, and an opportunity to continue it in connection with the college museum. During his third and fourth college years he had especial privileges for advanced work in botany and zoölogy, and was in charge of the college museum.

Obtaining the bachelor's degree from Amherst in 1891, he spent one year at the Museum of the Worcester Natural History Society, one year in graduate study at Harvard, and two years as instructor at Amherst, which conferred upon him the degree of M.A. in 1895.

Of his work at Amherst Professor Tyler says, in a letter recently received: "It always seemed as if he was working purely for the enjoyment of it. He was a very hard worker, and made his students work. The best men did so because they caught his spirit, the others because they had to. He made things very clear, and always knew what to tell and how much to leave to the student to find out. He never made his teaching a mere memorizing of dry details."

In 1895 Mr. Morris removed to Washington, D. C., and for twelve years was connected with the school system of that city, for the last seven years being head of the department of biology. His progressive teaching here developed a course in biology

that reached the life and activities of young people. He always taught as if in the laboratory, arousing the interest of his students, stimulating them to seek first-hand knowledge, teaching them that biology was a matter of everyday life, and training them to think clearly and hard. During the year 1907, Mr. Morris resigned his position in Washington to become curator of natural science in the Museum of the Brooklyn Institute of Arts and Sciences, a position which he held at the time of his death. For one year, also, after the resignation of Dr. Lucas, he was acting curator-in-chief. This position gave him the chance to develop the ideas of the educative value of museum collections that he had long held. Believing that exhibition specimens should always arouse the desire for further information, he not only saw that the books furnishing such knowledge were close at hand, but insisted that every visitor should have, if he desired, the opportunity of personal conversation with the curator.

In addition to professional duties, Mr. Morris found the time to take an active part in general scientific work, his own motto for such things being, "Make both tie for first place." In Washington he was a member of the botanical, biological, and entomological societies, and of the Cosmos Club, but most closely identified with the Washington Biologists' Field Club, of which he was a founder and leading spirit. No one who knew him at "The Island" could fail to see how very close to his heart the success of the Club was, or forget how enthusiastically he entered into the plans for its development. Even after leaving Washington he kept in close touch with all that went on at the Club, and never failed to revisit it when circumstances permitted. He had made a large collection of plants from the Club property, which he hoped to make the basis for a detailed catalogue.

For years Mr. Morris's especial pleasure had been the systematic study of the Plantaginaceae, of which he had accumulated a large amount of material, many species being represented by alcoholic as well as ordinary herbarium specimens. It was a source of keen regret to him that increasing duties encroached upon the leisure hours that he preferred to spend upon his collections. The characteristic desire for accuracy delayed the publication of many conclusions that had already been attained,

conclusions that it is hardly possible to reconstruct from the notes available.

Besides what has already been mentioned, Mr. Morris was for a short time associate editor of School Science and an associate examiner on the College Entrance Examination Board. At the time of his death he was editor of the Torrey Botanical Club, of which he had been a member since 1901. In 1898 he collected for the United States National Herbarium on the Florida Keys, and in 1900 was an assistant upon the staff of the United States Fish Commission in West Virginia. For four years he was a special plant expert of the Department of Agriculture, doing field work in Oregon, along the Great Lakes, and in Iowa. In 1908 Mr. Morris was secretary of the Nomenclature Commission of Section G of the American Association for the Advancement of Science, and in 1911 was elected a fellow of the Association.

Mr. Morris was twice married, his first wife being Florence Syvret, of Charlton, Mass., who died in 1903. In 1907 he married Mary E. Bedell, of Washington, D. C., who, with a son, survives him.

NEW YORK CITY

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The ferns and flowering plants of Nantucket—XI

Eugene P. Bicknell

CELASTRACEAE

*Celastrus scandens L.

Rare; it is found sparingly on Coskaty entwined with wild rose and red raspberry near the harbor shore, and in Shawkemo, where it is massed thickly along a low bank back of the beach. Flower buds June 4, 1909; first flowers June 2, 1911.

ACERACEAE

Acer rubrum L.

In swamps and low grounds. It is commonly of no greater stature than a shrub, but in sheltered thickets becomes a well-developed tree, and in Beechwood has attained a height of not less than thirty to thirty-five feet, the trunks thirty to thirty-five inches in basal girth. The leaves of different trees are widely variable, sometimes appearing much like those of *Acer carolinianum*, again taking an elongated form with narrowly cleft attenuate and sharply cut lobes.

*Acer carolinianum Walter.

Frequent in boggy thickets, sometimes side by side with those forms of *Acer rubrum* with which it is most sharply in contrast. It is a tree of marked individuality when appointed in its true features but these are not always well expressed and its divergence from the red maple cannot be said to have passed into a fixed separation. In its most characteristic forms the small thickish leaves, rather clustered at the ends of the branchlets, are of rounded outline and broadly notched into three short lobes, the blades, only 4–6 cm. long and wide, having the upper surface of a dark shining green, the lower surface conspicuously whitened and more or less pubescent.

*ACER SACCHARINUM L.

A. dasycarpum Ehrh.

About two miles from the town scattered among an open growth of pines off the Wauwinet road are to be found a few small silver maples not over three or four feet in height. They were first observed in 1909.

*ACER PLATANOIDES.

The Norway maple has been little used on Nantucket, but is self-seeded in planted grounds and has occasionally grown up into small trees in neglected places.

*ACER PSEUDO-PLATANUS L.

Many fine sycamore maples shade the streets of the town and produce a numerous progeny of seedlings some of which persist and grow into small trees in out of the way places. In full flower along the streets June 6, 1909.

The three introduced maples here mentioned have only the slenderest claim to be included in the island's wild flora and are reported mainly for purposes of record as widely cultivated trees which are tending to become naturalized.

BALSAMACEAE

IMPATIENS BIFLORA Walt.

Common in low grounds often bordering thickets or growths of rankly growing taller plants. A form occurs having very pale or whitish spotted flowers. First flowers July 1, 1912; blooms through September.

VITACEAE

VITIS LABRUSCA L.

Very common generally and in many places conspicuous from its luxuriant growth. It thrives in low thickets draping the shrubbery and strays into open places, trailing among the grass and herbaceous plants or even sprawling in bare sandy fields. Flower buds June 12, 1909; first flowers June 17, 1908; June 18, 1910; well-formed green fruit June 27, 1912.

The fruit may be of the largest size and deep purple or amber purple in color, or much smaller, more numerous and crowded

in the clusters, and greenish or greenish purple even when fully ripe. This pale-fruited form is locally abundant on Marthas Vineyard, where it is often wholly green at maturity and is known to the islanders as the white wild grape. I did not myself see it growing there, but, on Sept. 28, 1911, was shown several large sacks filled with the perfectly ripe green fruit which, in gathering, had been kept separate from the usual purple kind.

VITIS AESTIVALIS Michx.

Found only on the eastern side of the island, where it is frequent or locally common in wet or dry thickets sometimes actually intertwined with *Vitis Labrusca*. It occurs in Shawkemo, Pocomo, Coskaty, and Squam, and south to Tom Never's Pond. Comes into flower rather later than *V. Labrusca*. Flower buds very small June 7, 1911, and June 13, 1908; first flowers June 26, 1910; still in bloom July 11, 1912. It appears to fruit only sparingly on Nantucket, although bearing abundantly on Marthas Vineyard. Fruit small and green Aug. 13, 1906; becoming purplish Sept. 11, 1907. On Marthas Vineyard much of the fruit was still unripe Oct. 5, 1912.

A very old vine near Abram's Point measured twenty-one inches around close to the base and seventeen inches a foot above.

PARTHENOCISSUS QUINQUEFOLIA (L.) Planch.

In thickets, either in low grounds or on the dry plains, sometimes trailing over banks clothed with crisp lichens and bearberry or even thriving in exposed white sand. Flower buds barely visible June 1, 1909, and June 14, 1911; no open flowers up to July 12, 1912.

The leaflets vary from glabrous to thickly pubescent with silvery hairs on the lower surface and to some extent on the upper surface also; this pubescence may extend thinly along the petioles but seems always to be absent from the branchlets and tendrils. It is a character that has been adduced as distinctive of *Parthenocissus hirsutus* (Donn) Small, but as to the pubescent Nantucket plant there seems little reason to doubt that it is merely a condition of the common Virginia creeper. The leaves of young plants are often very pubescent, and in older plants the lower leaves may be pubescent and the later ones quite glabrous.

MALVACEAE

MALVA ROTUNDIFOLIA L.

An abundant weed, flowering freely from May through September and doubtless until frost.

*MALVA VERTICILLATA L.

The herbarium of the Nantucket Maria Mitchell Association contains a specimen of this mallow, collected by Mrs. Nellie F. Flynn, bearing the record "Waste place, Sept. 22, 1902."

*MALVA MOSCHATA L.

Several white-flowered plants in full bloom July 9, 1912, in a vegetable garden at Surfside; Surfside, Aug. 1909, Mrs. Mary A. Albertson; lane off Madequet road, 1905, Mrs. Eleanor W. Morgan, *fide* F. G. Floyd.

*ALTHAEA ROSEA Cav.

Freely spontaneous by street sides and in neglected places about the town and appearing occasionally in waste lots in the suburbs. The seedling plants begin to spring up at the end of May. Just in flower in several waste spots July 12, 1912.

HIBISCUS MOSCHEUTOS L.

When in bloom the rose-mallow is conspicuous at a number of the shore ponds on the northern and eastern sides of the island, but it seems to be quite wanting about the ponds on the south shore. At most of its localities it is not abundant, although growing in profusion at a few places. It is found at Capaum Pond, Reed Pond, Monomoy, Shimmo, Squam Pond, and on Coskaty, where it was in full bloom Aug. 16, 1906. Flowers observed as late as Sept. 11, 1907.

Mr. Floyd's notes refer to a form having white flowers with a crimson eye found by a small pond in Monomoy by Miss Mary Foster Coffin. It is not improbable that this may have been *Hibiscus oculiroseus* Britton, which is not rare on Long Island.

HYPERICACEAE

ASCYRUM HYPERICOIDES L.

Long known from Nantucket, the northeastern limit of its range, but not at all a scarce plant there, as has been supposed.

It is, however, confined to the eastern side of the island, where it is locally common from Wauwinet to Quidnet, extending west to Beechwood and south to beyond Sachacha Pond. In full flower Aug. 7, 1906; continues to bloom until late in September. It often spreads out into patches of considerable size, which become noticeable from their light green color as early as the middle of June.

HYPERICUM ADPRESSUM Bart.

Common about several ponds in Polpis and Saul's Hills; west of Sachacha Pond; Waqutuquaib Pond; Miacomet Pond; a single early flower July 11, 1912; in full flower Aug. 7, 1906; Sept. 1, 1904; some flowers remaining Sept. 18, 1907. The young plants have become several inches high by the middle of June.

Early in the season this St. John's-wort may be seen in small ponds either wholly submerged or showing emersed leafy tips. Later, when the waters have fallen, such plants often develop with unusual vigor, becoming fully two feet high with the leaves proportionately enlarged and the submerged portion of the stem greatly thickened with spongy tissue (var. *spongiosum* Robinson). Where colonies of the plant extend back from a flooded shore a complete gradation may be traced from this spongiose aquatic condition to the more usual terrestrial state. The latter comes earliest into bloom, the most dwarfed examples of the driest situations flowering first and often precociously.

The spongiose tissue is doubtless homologous with the aerenchyma produced on the floating stems of *Decodon verticillatus*. A slight but evident spongiose enlargement of the lower part of the stem is sometimes seen in *Hypericum canadense* and in *Hypericum boreale* when these low ground plants grow in very wet places.

HYPERICUM PERFORATUM L.

One of the bright-flowered weeds of fields and waysides, and scattered widely over the plains and commons. First flowers June 27, 1910; June 29, 1912.

HYPERICUM PUNCTATUM Lam.

Not common but found sparingly at a number of widely separated stations, mainly on the eastern side of the island; not

observed west of Maxcy's and Hummock Ponds. Plants of full size June 15, 1911; small flower buds June 11, 1912; in full flower and with some mature pods Aug. 16, 1906. So far as observed, the Nantucket plant has always sessile broadly clasping leaves.

*HYPERICUM BOREALE (Britton) Bicknell.

This is the commonest *Hypericum* of the island, abounding in low grounds, damp or wet sandy places, and pond shores. It is sometimes aquatic, inhabiting deep water with the habit of a *Callitriche*, the elongated leafy stems either wholly submerged or their tips emersed. In wet sand it may become strongly stoloniferous, putting forth prostrate basal offshoots which reach a length of several inches and root at intervals, sending up small flowering stems and terminating in a cluster of stems from the rooted tip. The young plants become recognizable early in June. Just in flower Aug. 13, 1906, remaining in bloom through September.

HYPERICUM MUTILUM L.

Common in low grounds, often with its characters unusually well emphasized, the broadly clasping leaves becoming as large as 3 cm. long by 2 cm. wide. The earliest leaves are observable at the end of May and the young plants take definite form early in June. In full flower Aug. 13, 1906; flowering through September.

*HYPERICUM MAJUS (A. Gray) Britton.

Infrequent, growing in damp places. West and southwest of the town; Trot's Swamp; Miacomet Pond; Quaise. Just in flower Aug. 11, 1906; in full flower Sept. 8, 1904; Sept. 12, 1907.

HYPERICUM CANADENSE L.

Common in low grounds and wet sandy places. Leaves often almost filiform linear. Plants very small May 30, 1909; a single early flower June 20, 1908, and July 3, 1912; in full flower and with mature capsules Aug. 13, 1906; continues in flower through September.

***Hypericum dissimulatum** sp. nov.

Erect, often from an oblique or horizontal rooting base, commonly 1.5–3 dm. high, exceptionally up to 5.5 dm., not often

branched below the middle; leaves narrowly oblong, obtuse, sessile or subclasping, 3–5-nerved, 1–3 cm. long, 2–6 mm. wide; branches slender, openly ascending, bearing dichotomous many-flowered bracteolate cymes, the bracts subulate; sepals oblong to lanceolate, obtuse or acutish, equaling or shorter than the capsules; capsules greenish to reddish purple, small, 2–4 mm. long, ellipsoid to conic-ovoid.

Maine to Maryland and North Carolina. Type from Nantucket, damp roadside west of the town, Sept. 20, 1899, in flower and fruit, in herb. N. Y. Botanical Garden. Also collected on Nantucket Sept. 8, 1904, Miacomet Pond, and Sept. 9, 1904, near the town.

This plant has been known to me for many years, having been collected first in York County, Maine, then on Nantucket, on Marthas Vineyard, where it is more common than I have found it elsewhere, and on Long Island. It is found in damp sandy places, usually growing with *H. canadense*, *H. majus*, *H. mutilum*, and *H. boreale*, one or all, and is not less distinct in appearance from each of them than are they among themselves. It differs from *H. canadense* in broader often subclasping leaves, more diffuse inflorescence, and smaller often ellipsoid capsules. Narrower leaves, more spreading and compound inflorescence, and smaller capsules distinguish it readily from *H. majus*, while it stands apart from *H. mutilum* by stricter, less branched habit, narrower less clasping leaves and longer, or more ellipsoid, purple capsules. Certain specimens approach *H. canadense* in the form and color of the pods, other examples seem nearer to *H. mutilum*, and it may well be questioned whether it be not a hybrid of these two species or, indeed, partly of *H. canadense* and *H. boreale* as some specimens might seem to suggest. But all of our small St. John's-worts of this group are nearly related and, considering the extended coastwise range of *H. dissimulatum*, as good reasons appear for viewing it as one of a chain of close species as for surmising that it may be a cross.

In addition to material from Maine, Nantucket, Marthas Vineyard, and Long Island, collected by myself, the following specimens may be cited:

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PENNSYLVANIA: Smithville, Lancaster County, *J. K. Small & J. J. Carter.*

MARYLAND: Hyattsville, Aug. 13, 1904, *H. D. House.*

NORTH CAROLINA: Mica, June, 1898, *C. W. Hyams.*

In herb. Columbia University:

NEW YORK: Springfield, L. I., 1896, *Elizabeth G. Knight;* New Dorp, Staten Island, Aug. 31, 1890, *N. L. Britton.*

SAROTHRA GENTIANOIDES L.

Abundant in dry sandy places, stems appearing June 15, 1911; in full flower in September. The plant may be actually minute, its simple stem bearing only a single flower, or densely branched to form a firm convex mass 1–1.5 dm. in diameter.

TRIADENUM VIRGINICUM (L.) Raf.

Very common in wet swamps and about the borders of muddy ponds. Earliest leaves May 31, 1908; no flowers remaining in September.

ELATINACEAE

ELATINE AMERICANA (Pursh) Arn.

Common in some of the sandy ponds, growing in shallow water near the shore. Observed especially in Maxcy's Pond, Miriam Coffin Pond, and Miacomet Pond. At Maxcy's Pond on Sept 12, 1907, it grew as profusely on the damp sand where the water had receded as beneath the surface along the shore. At one spot in heavy mud ten yards or more from the water's edge it had formed compacted moss-like mats, some of them six inches across, a mode of growth remarkably unlike that of the submerged plant. Correlated with this difference in habit ran a variation in characters which was brought out strikingly by comparison of the living plants. In water and on damp sand the individual plants were separate in growth, uniformly simple-stemmed, and whitish or pale green in color. In the mud form the matted stems were often divergently much branched and the general color a lively green tinged with reddish or purple, these tints deepening on the capsules into bright crimson; instead of greenish white the petals were rose color and were sometimes as large as 1.5 mm. in breadth. The capsules, some being four-valved, were larger than those of

the submerged plant and of a distinctly different form, depressed-subglobose and wider than long instead of broadly obovoid and longer than wide; actual measurements were 2 mm. wide by 1 mm. long in the terrestrial plant and only 1–1.5 mm. wide by 1 mm. long or more in the normal aquatic form.

CISTACEAE

CROCANTHEMUM CANADENSE (L.) Britton.

Helianthemum canadense Michx.

The typical plant is not common and is rather local in its distribution, giving place to the following, which is everywhere abundant. It is however frequent in the oak barrens towards Siasconset and is found sparingly in Quaise, on the plains towards the south shore, on Great Neck and elsewhere. No flower buds visible June 3, 1909; first flowers June 11, 1909; in full flower June 19, 1910; a few flowers remaining June 30, 1912. Reduced petaliferous flowers are often produced in September.

***Crccanthemum dumosum** sp. nov.

Similar to *Crocanthemum canadense* but lower and of more branched and spreading habit, commonly diffuse and semi-prostrate or ascending, the pubescence somewhat more densely and softly canescent, intermixed with scattered non-stellate longer hairs and some minute glandular hairs of a reddish color; leaves smaller and shorter than those of *C. canadense* and of a more bluish green color, mostly oval and elliptic and obtuse, often very small and crowded on the short divergent branchlets; flowers slightly paler than in *C. canadense;* mature calyx often larger, the sepals very broad and mostly acuminate, usually bearing reddish papillae on the outer surface and reddened glandular or viscid hairs in the pubescence; primary inflorescence an ascending succession of single petaliferous flowers succeeded by rather numerous flowers intermediate in size and character between these and the later apetalous ones.

Well marked and abundant all over Nantucket, combining with such common and characteristic island plants as *Amelanchier nantucketense*, *Ilex fastigiata*, and *Linum intercursum* to stamp the flora with a signally distinctive character. It is found also on Marthas Vineyard and on the Hempstead Plains of Long Island.

Blooms rather earlier than *C. canadense*. First flowers May 31, 1909, and quite generally in bloom June 1; June 3, 1911; still some flowers June 26, 1910. At one station a number of clustered plants bore flowers so pale in color as to appear almost white.

Type from Nantucket, Sept. 21, 1899, in herb. N. Y. Botanical Garden.

The typical form of the plant has an unlikeness to typical *Crocanthemum canadense* greater than appears between some other closely allied species within the genus, and this diversity of aspect becomes especially striking when, as is sometimes the case, the two are found growing near together. Typical *C. canadense* is a taller erect plant with lighter-colored stems and longer and more slender and simple ascending branches, narrowly oblong or oblanceolate leaves tapering to the base and the acute apex, brighter green on the upper surface and less densely pubescent. Ordinarily it holds very true to these characters, showing little tendency to marked variation. In several instances where the two plants growing near together allowed a close comparison of the open flowers, those of *C. dumosum* were seen to be notably the larger, the acuminate sepals reaching a length of 8–10 mm. and reddened with glandular hairs and papillae, while those of *C. canadense*, narrower and mostly obtuse, were but 5–7 mm. long and only obscurely if at all glandulose. These differences are not, however, always so well marked. Nevertheless *C. dumosum* is evidently a strongly established derivative of *C. canadense*, even if it be not yet wholly disconnected from that species. It has been a recurring source of confusion to not a few Nantucket collectors and it seems altogether expedient to dispose of it as a stumbling block by giving it identity by a name.

*CROCANTHEMUM MAJUS (L.) Britton.

Helianthemum majus B.S.P.

Rather common on the plains towards the south shore; elsewhere very local although widely scattered, but wanting over a great part of the north and east sides of the island. No visible flower buds June 22, 1910, July 2, 1912; first flowers July 10, 1912. small petaliferous flowers sometimes appear in September.

***Crocanthemum propinquum** Bicknell.

Helianthemum propinquum Bicknell.

Rather local, but not uncommon in dry open places or along sandy roadways through pine barrens. Common on Marthas Vineyard. In full bloom June 26, 1910; not many flowers left June 29, 1912; a few belated flowers July 11, 1912.

This plant, not at all uncommon from Nantucket to western Long Island and doubtless further south, appears to remain almost unknown to botanists and seems not to have been reported by any collector since it was first described in Britton's Manual over eleven years ago. In the seventh edition of Gray's Manual it has been quite misunderstood, being mistaken for the plant described in this paper as *Crocanthemum dumosum* and referred to as being probably only a stunted form of *C. canadense.*

I know the plant now much better than when I ventured to give it a name and have found no reason to doubt that it is an unequivocal species, that is to say, one that is organically discrete from those allied species which most nearly approach it, however close the degree of their relationship. Narrow indeed is the interval between this plant and those other convergent species whose distribution it partly shares. But I have not found in this any proof of consanguinity but rather an example of the exceeding closeness in which specific lines may run in perfect security from coalescence or entanglement. The plant is to be viewed critically especially in its relation to *C. majus.* Its clustered primary flowers at once give this indication and mark its distinctness from *C. canadense.* Singularly enough, however, in the later stages of its growth it more nearly resembles the latter, agreeing in color of foliage and slender ascending branches surpassing the primary inflorescence. This character of the mature plant sketches it out clearly from *C. majus*, of strict habit and short close branches, but in its unbranched early-flowering stage, then also of paler foliage, it is almost a reduced counterpart of the larger plant.

To review its differences from *Crocanthemum majus*, it is a much smaller and more slender and flexuous plant, at length more openly and slenderly branched, less densely canescent from the first and finally much greener, the leaves narrower and more

obtuse, often spatulate-linear, and usually on more obvious petioles; the primary inflorescence is of more delicate and open structure, the flower buds elliptic in form rather than ovoid, the calyx becoming notably larger, 8–10 mm. long, and often strongly reddish-tinged, thus equaling in length the largest calices of *C. canadense* as well as corresponding in color, although with narrower sepals and wanting the characteristic pilose hairs; the narrow outer sepals are shorter than in *C. majus*, and the even smaller petals are of rather a brighter yellow; the primary capsules are smaller, thinner-walled, and less broadly ovoid, longer than wide instead of wider than long, and are without the umbonate tip; it is, in fact, much more like the capsule of *C. canadense*, although smaller and narrower; the papillose seeds are also much like those of *C. canadense*.

There is nothing in all this that denotes the plant to be necessarily of mixed strain, nor do my observations lead me to believe that it is a hybrid. It does indeed possess in combination the early flowering time of *Crocanthemum canadense* and the smaller pale yellow flowers of *C. majus*, together with the slender branching of the one and the clustered petaliferous flowers of the other, yet its capsule has not its counterpart in that of either, nor is it intermediate with them, being smaller and less broadly ovoid. The plant stands apart from these companion species also in its small size and more delicate structure, in the prevailing form of the leaves and in its non-cespitose habit. Its slender stems, although sometimes loosely clustered, commonly arise at distinct, even remote intervals along tortuous elongated rootstocks, forming open groups or larger patches, sometimes several feet in diameter. It is rarely found associated with more than one of its close allies, often, indeed, occupying territory where not either one of the others is found at all.

The relationship of *Crocanthemum propinquum* to the little-known *C. georgianum* of the southern states is evidently close, although, according to Dr. Small, the latter possesses the very distinct character, as compared with the northern group of species, of bearing the petaliferous and apetalous flowers in the same clusters.

HUDSONIA ERICOIDES L.

Few plants of Nantucket spread over the island more widely or in greater abundance than this little heathlike species and not one is more conspicuous in the landscape when in full bloom. Nor is there any other that, at flowering time, puts its scene in color with quicker transformation, for there come seasons when it bursts into bloom on all sides in the hours of a single hot morning.

Earliest flowers May 30, 1909, quite generally in bloom June 2; first flowers June 4, 1911, in the early morning, everywhere in flower by noon; abundantly in bloom June 7, 1908, inflorescence becoming brown by the 13th and but few flowers remaining on the 18th; in the season of 1910 it had passed flowering in exposed places June 20, although still blooming freely in the shade of pine groves.

After full bloom it remains for one or two weeks the season's most conspicuous flower, spreading its sheets of gold along the roadways and over acres of plain and hillside, a radiant sight. A few days later the flowers are withered and the wide tracts that had glowed with their color become brown and rusty as if seared by fire.

In open sandy places where this plant has formed the compact circular cushions that are one of its modes of growth, the flowers usually open first close to the ground on the side towards the morning sun, blending together in patches of expanding brightness as they continue to unfold. Gradually as the sun rises overhead the glow of color creeps back along the borders of the tuft, sometimes uniting around its circumference in a golden ring. Soon afterwards the entire tuft has become an unbroken mass of bloom.

Often in midsummer these cushion-like tufts even in the hottest and most exposed sandy spots remain fresh and green in bright contrast to their parched surroundings, calling to mind so remote a comparison as the stones along a woodland brook covered with green moss.

In open pine scrub south of the town on June 5, 1911, several patches of this plant, all near together, bore flowers of palest sulphur-yellow, in striking contrast to the normal bright yellow flowers everywhere about them.

HUDSONIA TOMENTOSA Nutt.

Very abundant, blanketing the dunes and reaches of white sand back of the beaches and occurring on sandy exposures all over the island. It is sometimes found in association with the preceding but seems not to mix readily with any other plant. Close to blooming June 3, 1911; in full flower June 7, 1908, June 15, 1910, and some flowers remaining June 27; last flowers July 2, 1912, on the exposed ocean front at Siasconset, where many plants flower later than in more protected parts of the island. Ordinarily it begins to flower a little earlier than *Hudsonia ericoides*.

LECHEA MINOR L.

Abundant on the eastern side of the island from Wauwinet to Saul's Hills and Siasconset, extending west to Shawkemo and through the South Pasture to Surfside; not seen on the western side of the island. The season's shoots a few inches high June 23, 1910.

LECHEA VILLOSA Ell.

Much less common than the preceding but like it restricted mainly or entirely to the eastern side of the island, having a scattered distribution from Wauwinet to Siasconset and the South Pasture and from Pocomo to Shawkemo and Saul's Hills.

LECHEA MARITIMA Leggett.

One of the island's most common plants, appearing everywhere in dry sandy soil, even to the tops of Saul's Hills. It makes its best growth in pure sand, where it becomes widely branched and densely canescent. In less simple soils amid the low vegetation of the moorland or in partial shade it is more thinly canescent and shorter-branched, having a narrower panicle and closer inflorescence. Such forms take on a likeness to *Lechea juniperina* that seems almost to shadow the origin of that more northern species. Sometimes on rising ground in open growths of pines or other trees it may become very slender and greener, with more scattered leaves and branches, more slenderly branched and open panicle of longer-pedicelled flowers and rather larger fruiting calyx—var. *interior* Robinson.

In full flower Sept. 3, 1904, Sept. 11, 1899; small new shoots

June 15, 1910. In the autumn, sometimes as early as September, the basal shoots may be found beneath the surface of the sand so densely invested with white pubescence as to appear as if coated with hoar frost.

*LECHEA LEGGETTII Britton & Hollick.

L. moniliformis Bicknell.

Not rare on the eastern side of the island from Wauwinet to Polpis, Gibbs' swamp and Tom Never's swamp; one station near Madequecham Pond on the south shore. It is found in low grounds spreading to dry sandy levels near wet places; in one instance it grew on the border of a sphagnum bog, and in another in wet soil along a brackish marsh.

Plants 6 inches high June 24, 1910; flower buds well advanced Aug. 7, 1906; some mature pods Aug. 31, 1904.

This, in its extreme phase, is the plant described by me some years ago as *Lechea moniliformis*. The type specimens, as well as others like them from Long Island, mark a pronounced departure from typical *L. Leggettii*. Other specimens from Nantucket and Long Island are less distinctive and I am in doubt whether it is well to rate the plant as other than a variety of the common species. Nevertheless, it has points of distinction which need no second glance to impress any one who may be familiar with the common inland form of the species, for *L. moniliformis* would appear to be a plant of the coastal plain, and there is as yet no evidence that it does not belong exclusively among our coastal plain species. Moreover it shows this difference in habits from the more inland plant of dry open places and hilly ground, that it is of low grounds often of wet and brackish soils. A better knowledge may show that its distinctive name should be restored, but for the present let it be merged with *L. Leggettii*. I take to be typical of the latter the plant that I used to find among the hills and rocky outcroppings along the Hudson near New York and which, found also in New Jersey and on Staten Island, largely made up the material studied by Leggett and by Britton & Hollick. As compared with this the main distinguishing characters of *L. moniliformis* are the slender and elongated flowering branchlets and the markedly secund and moniliform inflorescence, for in the

typical plant the ultimate inflorescence takes a short corymbulose rather than a slenderly racemulose plan. These flexuous branchlets are often borne on short spreading branches crowded on the upper part of the stem, producing a broadly ovoid or obovoid, often dense and very leafy panicle instead of a more oblong and open one. The leaves, similar to those of *L. Leggettii* proper, are rather longer and more tapering acute and narrowed into more evident petioles 1–2 mm. long. The mature calyx and pod is commonly larger and more elliptic than in the typical plant and is usually further distinguished by its decidedly purplish color; also the capsule is rather more exserted and often more distinctly short-stipitate, and the general pubescence is sparser and of rather longer and looser hairs.

Note.—Lechea racemulosa Lam. was attributed to Nantucket by Mr. Leggett and is reported by Mrs. Owen as having been found there by Mr. Dame. There would seem to be little reason to doubt that these records were based on mistaken determinations.

VIOLACEAE

VIOLA PEDATA L.

The commonest blue-flowered violet of Nantucket, broadcast on the plains and commons and among open growths of scrub pines. The flowers are often small for the species and of deep color, varying to pale lilac and sometimes pure white.

The spring flowers of Nantucket are late in coming, and this violet, which on Long Island colors acres of the Hempstead Plains from April, in early seasons, until the middle of May or, in later seasons, till the end of the month, is commonly in full bloom on Nantucket from late in May until after the middle of June. In the forward season of 1908 no flowers were to be found after June 15, but the following year children on their way to school were seen carrying large bunches on June 6, and it was blooming in profusion as late as June 12. Flowers are occasionally produced in midsummer and, more frequently, in September.

On Sept. 1, 1904, among scrub pines where, earlier in the year, fire had passed, destroying the herbage, many of these violets had sprung up afresh and were in full bloom. The leaves of all differed curiously from their normal form, being narrowly to

broadly cuneate and flabellately cleft into irregular lobes of varying length and breadth. Plants with similar leaves collected June 12, 1908, were rooted deep in heavy yellow sand and, like those of the burned-over tract, had doubtless suffered some disturbance of their normal course of growth.

*VIOLA OBLIQUA Hill.

Viola affinis LeConte. See Bull. Torrey Club 40: 261–270. 1913.

On a shaded bank at Watts Run, an abundant growth, and sparingly in a not distant thicket in Squam; also in the shade of a willow by a bog hole west of Trot's Swamp. In full flower as late as June 9, 1909.

Becoming 3.5 dm. high, or more; leaves thin, from narrowly to broadly cordate-ovate, attenuate to acuminate, acute, in age widely dilated at base and broader than long, the largest 9 cm. wide, the upper surface with some minute appressed hairs; sepals ovate to ovate-lanceolate, obtuse, flowers often becoming upturned; peduncles of apetalous flowers of very variable length even on the same plant, declined, ascending or sometimes strictly erect and over 1.5 dm. high; capsules mostly blotched with purple, sometimes pale, the expanded valves 7–10 mm. long; seeds pale.

*VIOLA PAPILIONACEA Pursh.

Viola cucullata of authors, not Aiton. See Bull. Torrey Club 40: 261–270. 1913.

Found only in a boggy meadow about a mile west of the town, growing sparingly with *Viola lanceolata;* in full flower June 1, 1909.

Plants rather small, somewhat tufted from multicipital root-stocks; scapes mostly not longer than the leaves; leaf blades cordate-ovate to triangular-cordate, crenulate-serrate, thinly pubescent on the upper surface with appressed silvery spiculae; sepals narrowly lanceolate, sometimes elongate, ciliolate; flowers pale blue, or deeper blue, much darker towards the throat.

VIOLA LAETECAERULEA Greene.

V. papilionacea of authors, in part, not Pursh. See Bull. Torrey Club 40: 261–270. 1913.

Found only in the town, where it is frequent by streetsides and in shaded yards, often forming close beds, and appearing as

if introduced. In flower June 3, 1909, June 7, 1911. Petioles more or less pubescent dorsally, sometimes densely villous, but more often glabrous, except towards the base of the blade; blades mostly with some pubescence beneath at the base or along the veins. When growing in damp shaded yards the leaves are thinner and brighter green, resembling those of *Viola obliqua;* plants more deeply set in looser and drier soils have duller leaves of thicker texture, the blades broadly reniform with wide sinus and rounded to the short-pointed apex, the margins more closely crenate-serrate; capsules green.

VIOLA FIMBRIATULA Sm.

Excepting *Viola pedata* no other blue-flowered violet is common on Nantucket. Therefore it might be thought that the purity of the *fimbriatula* line would be wholly uncontaminated, and that variation in the species might be seen in its intrinsic phases free from any influence of hybridization. Nevertheless, the variation shown under this insular seclusion is not less remarkable than is commonly the case elsewhere, where associated species may be supposed to have had their influence. The more common form on Nantucket has ovate-oblong subcordate leaves little if at all incised and often as long as the petioles. A coarser form has longer petioles and larger blades, which become 5 cm. or more wide across the subtruncate base. In bare spots on clayey soil are found very small forms with ovate to ovate-lanceolate subentire leaves narrowed into short petioles and crowded in a close rosette against the ground. In shade among the Miacomet pines there is a form having considerable pubescence but otherwise showing something of the aspect of *Viola sagittata*, many of the narrow and long-petioled leaves being rather deeply cordate and saliently dentate at the base with upcurved acute teeth and, notwithstanding their pubescence, appearing bright green and shining on the upper surface; the flowers are deep purple with the rather narrow petals often crenulate and obscurely pointed.

A series of Nantucket specimens was submitted to Doctor Brainerd who says of them, referring especially to the *sagittata*-like plants: "Your plants are not strictly hybrids but intermediate

forms which have probably resulted from hybridization in the indefinite past. We have no pure *Viola sagittata* in Vermont, but most of your odd forms turn up from time to time in the Champlain valley."

*VIOLA FIMBRIATULA Sm. × OBLIQUA Hill.

A single cluster growing with *Viola obliqua* on a shaded bank at Watts Run, June 9, 1909.

Petioles and peduncles pubescent with short spreading hairs, the leaf blades similarly clothed on the veins beneath, sparsely appressed-pubescent on the upper surface, ciliate; later leaves ovate-oblong and openly cordate, or somewhat attenuate-triangular from a subtruncate base, coarsely and rather closely sinuate-dentate towards the base, the largest 6 cm. wide by 9 cm. long on petioles 10–15 cm. long; apetalous flowers few, mostly weakly developed, the buds lanceolate and acute, their petioles ascending-horizontal or declined.

This plant grew in shade beside a mass of *Viola obliqua*. No *Viola fimbriatula* was found with it, but the specimens are obviously intermediate between these two species, and on Nantucket no others are possibly to be assigned as parents.

*VIOLA ODORATA L.

An old garden plant of the town, here and there strayed along streetsides and established in neglected yards. One particular tuft has grown for many years in a crevice between the paved sidewalk and a brick wall on North Water Street. It was first noticed in 1899, and has been found at the same spot on every subsequent visit to the town, evidencing both the tenacity of the plant and the undisturbed repose of the town streets.

VIOLA LANCEOLATA L.

Very common in bogs and low grounds and in wet sandy soil about the borders of ponds. In full flower May 30, 1908, June 3, 1909, June 3, 1911, and still commonly in flower June 15; some flowers remaining June 25, 1910.

Plants growing with *Viola pallens* and appearing more or less intermediate with it, and others approaching *Viola primulifolia* are not improbably hybrids.

*VIOLA PRIMULIFOLIA L.

Less common than the preceding and often found in drier soils. In full flower May 31, 1908, June 1, 1909; last flowers June 17, 1910, June 15, 1911.

VIOLA PALLENS (Banks) Brainerd.

Common in open sphagnum bogs and meadows and in damp thickets. No flowers left May 31, 1908, June 7, 1909; still blooming June 3, 1910, a few last flowers June 8, 1911.

A form of distinct appearance was found in several wet sphagnum bogs, especially in one near Shawaukemmo Spring. It is strictly glabrous throughout, the scapes and petioles delicately streaked with pink, the leaf blades unusually thick and veiny, becoming as large as 5 cm. in breadth, and varying in shape from long-ovate and deeply cordate to broadly cordate-reniform; petioles sometimes 9 cm. long; longer peduncles 1.5 dm.; capsules green; seeds 1–1.25 mm. long, dark gray to nearly black when mature. Doctor Brainerd, who has examined specimens, regards it as a form of *Viola pallens*.

Note.—Viola blanda Willd. which proves to be common on Marthas Vineyard is to be looked for on Nantucket.

NEW YORK CITY

The influence of starch, peptone, and sugars on the toxicity of various nitrates to Monilia sitophila (Mont.) Sacc.

Otto Kunkel

Introduction

Winogradsky and Omeliansky (7) found that the addition of .05 per cent of glucose or asparagin to nitrite-media hindered the development of the nitrate-bacteria. Peptone at a somewhat greater concentration was also detrimental. These substances are widely used in the preparation of culture media, but have been given little attention by investigators of the problems of toxicity.

Fluri (2) has reported that the salts of aluminum render the protoplasm of *Spirogyra* and other water plants permeable and are, therefore, injurious to these plants. He found, however, that if glucose, glycerin, or isodulcitol are mixed with the aluminum salt it loses its power of rendering the protoplasm permeable. Thus the toxicity of aluminum salts to these plants depends upon whether or not glucose, glycerin, or isodulcitol are present in the medium. Quite recently Schreiner and Skinner (4) have reported that the toxicity of the organic poison cumarin is counteracted by phosphates, thus indicating a relation between the organic and the inorganic part of the medium.

In view of these results it has seemed worth while to investigate the influence of organic substances on the toxicity of inorganic salts. It has been my object to determine the toxicity of different salts in the presence of certain inorganic substances that are much used in the preparation of culture media.

Material and methods

I have used the fungus *Monilia sitophila* in all of my experiments and have found it well suited to my purpose. Some of the things that recommend it are as follows: (1) It is a rapid grower. On a favorable medium at room temperature it will produce spores

in fifteen hours. (2) It is able to use as a partial source of its food supply a rather large number of organic compounds. Went (6) has found that it grows well on media containing any one of the following substances: maltose, trehalose, raffinose, saccharose, cellulose, starch, fats, and proteids. This makes it especially suitable for experiments in which the organic part of the medium is to be varied.

All of my cultures were grown in Petri dishes that were previously immersed for at least ten hours in cleaning solution made according to Duggar's method (1). In the preparation of media and for rinsing glassware redistilled water was used.

In the tables that follow, the zero sign indicates that none of the spores on the medium in question had germinated, the minus sign indicates that germination and microscopic growth had taken place, while the plus sign indicates that growth was visible to the naked eye. All cultures were incubated at room temperature (about 22° C.).

In order to determine whether or not the toxicity of various salts to *Monilia sitophila* is influenced by sugars, starch, or peptone, each of these organic substances was used separately in testing the toxicity of the inorganic salts. I have designated the highest concentration of a salt that would permit germination of the spores in a given medium, as the limit concentration for that medium. A number of preliminary experiments were made to determine the approximate value of the limit concentration for each salt in each medium used. The results obtained in a final set of experiments are shown in the tables given below.

EXPERIMENTAL

Monilia will produce a considerable growth of mycelium and will ripen spores on a medium made by adding 5 grams of corn-starch to 95 cubic centimeters of redistilled water. The results obtained in a series of experiments in which different inorganic salts were added to this medium are shown in TABLE I. The concentrations varied from 1.33 molar for potassium nitrate to .000004 molar for zinc nitrate.

The table shows at a glance the increasing toxicity of the nitrates used, in the order in which they are arranged in the table

TABLE I

THE TOXICITY OF INORGANIC SALTS TO MONILIA SITOPHILA GROWN ON STARCH MEDIA

Medium									Growth after 11 days
1.33	molar solution of	potassium	nitrate		+	5%	starch	.....	−
1.06	"	"	"	"	+	"	"	.....	−
.80	"	"	"	"	+	"	"	.....	+
.53	"	"	"	"	+	"	"	.....	+
.26	"	"	"	"	+	"	"	.....	+
.13	"	"	"	"	+	"	"	.....	+
.667	"	"	"	calcium	+	"	"	.....	−
.533	"	"	"	"	+	"	"	.....	+
.400	"	"	"	"	+	"	"	.....	+
.267	"	"	"	"	+	"	"	.....	+
.133	"	"	"	"	+	"	"	.....	+
.067	"	"	"	"	+	"	"	.....	+
.034	"	"	"	"	+	"	"	.....	+
.667	"	"	"	sodium	+	"	"	.....	0
.533	"	"	"	"	+	"	"	.....	0
.400	"	"	"	"	+	"	"	.....	−
.267	"	"	"	"	+	"	"	.....	+
.133	"	"	"	"	+	"	"	.....	+
.067	"	"	"	"	+	"	"	.....	+
.034	"	"	"	"	+	"	"	.....	+
.187	"	"	"	barium	+	"	"	.....	0
.156	"	"	"	"	+	"	"	.....	−
.125	"	"	"	"	+	"	"	.....	−
.094	"	"	"	"	+	"	"	.....	−
.062	"	"	"	"	+	"	"	.....	+
.031	"	"	"	"	+	"	"	.....	+
.007	"	"	"	"	+	"	"	.....	+
.500	"	"	"	urea	+	"	"	.....	0
.250	"	"	"	"	+	"	"	.....	0
.125	"	"	"	"	+	"	"	.....	0
.063	"	"	"	"	+	"	"	.....	0
.050	"	"	"	"	+	"	"	.....	−
.025	"	"	"	"	+	"	"	.....	+
.013	"	"	"	"	+	"	"	.....	+
.006	"	"	"	"	+	"	"	.....	+
.050	"	"	"	ammonium	+	"	"	.....	0
.038	"	"	"	"	+	"	"	.....	−
.025	"	"	"	"	+	"	"	.....	+
.013	"	"	"	"	+	"	"	.....	+
.006	"	"	"	"	+	"	"	.....	+
.0075	"	"	"	aluminum	+	"	"	.....	0
.0063	"	"	"	"	+	"	"	.....	0
.0050	"	"	"	"	+	"	"	.....	0
.0038	"	"	"	"	+	"	"	.....	0
.0025	"	"	"	"	+	"	"	.....	0
.0013	"	"	"	"	+	"	"	.....	−

.0006	molar	solution	of	aluminum	nitrate	+	5%	starch	.....	+
.00133	"	"	"	ferric	"	+	"	"	.....	0
.00067	"	"	"	"	"	+	"	"	.....	−
.00053	"	"	"	"	"	+	"	"	.....	0
.00040	"	"	"	"	"	+	"	"	.....	−
.00027	"	"	"	"	"	+	"	"	.....	+
.00013	"	"	"	"	"	+	"	"	.....	+
.00007	"	"	"	"	"	+	"	"	.....	+
.00133	"	"	"	silver	"	+	"	"	.....	0
.00067	"	"	"	"	"	+	"	"	.....	0
.00053	"	"	"	"	"	+	"	"	.....	0
.00040	"	"	"	"	"	+	"	"	.....	0
.00027	"	"	"	"	"	+	"	"	.....	0
.00013	"	"	"	"	"	+	"	"	.....	−
.00007	"	"	"	"	"	+	"	"	.....	+
.000338	"	"	"	zinc	"	+	"	"	.....	0
.000254	"	"	"	"	"	+	"	"	.....	0
.000169	"	"	"	"	"	+	"	"	.....	0
.000082	"	"	"	"	"	+	"	"	.....	0
.000043	"	"	"	"	"	+	"	"	.....	0
.000034	"	"	"	"	"	+	"	"	.....	0
.000025	"	"	"	"	"	+	"	"	.....	−
.000017	"	"	"	"	"	+	"	"	.....	+
.000008	"	"	"	"	"	+	"	"	.....	+
.000004	"	"	"	"	"	+	"	"	.....	+
.5000	"	"	"	ammonium	tartrate	+	"	"	.....	0
.2500	"	"	"	"	"	+	"	"	.....	0
.1250	"	"	"	"	"	+	"	"	.....	0
.0625	"	"	"	"	"	+	"	"	.....	0
.0500	"	"	"	"	"	+	"	"	.....	0
.0250	"	"	"	"	"	+	"	"	.....	−
.0125	"	"	"	"	"	+	"	"	.....	+
.0063	"	"	"	"	"	+	"	"	.....	+
				redistilled	water	+	"	"	.....	+

from potassium to zinc. *Monilia* made sufficient growth to be easily visible to the naked eye in the starch medium containing potassium nitrate at a concentration of 0.8 molar or less, while at a concentration of 1.33 molar the spores germinated and produced microscopic growth. In a starch medium containing calcium nitrate at a concentration of 0.667 molar, the spores germinated but produced such a small amount of mycelium that it could be observed only with the aid of the microscope. It is interesting to note that after three days no germination had taken place in this medium. This shows that in such concentrations growth is very slow. In all media containing calcium nitrate at a concentration of 1.33 molar or less, there was abundant growth.

When sodium nitrate at a concentration of 0.533 molar was combined with the starch medium no germination occurred. When the concentration was 0.400 molar a small amount of growth was obtained. In still lower concentrations enough mycelium was produced to be easily visible to the naked eye. It was found that growth was much retarded in media containing the higher concentrations of sodium nitrate. This shows that near the limit concentration the rate of growth of *Monilia* decreases as the amount of sodium nitrate is increased.

Barium nitrate in the starch medium at a concentration of 0.187 molar inhibits the germination of the spores. At a concentration between 0.156 molar and 0.094 molar, the spores germinate but produce such a small amount of mycelium that it is not visible except under the microscope. At a concentration of 0.062 molar or less, good growth was obtained.

When the concentration of urea nitrate in the starch medium was 0.125 molar, the spores were unable to germinate. When the concentration was reduced to 0.063 molar, the spores germinated but produced such a small amount of mycelium that it was not visible to the naked eye. Good growth was obtained when the concentration of urea nitrate was 0.05 molar or less.

In starch media containing ammonium nitrate at a concentration of 0.05 molar none of the spores germinated, but when the concentration was 0.038 molar, they germinated and produced microscopic growth. When the concentration was reduced to 0.025 molar or less, abundant growth occurred.

Aluminum nitrate in starch media at a concentration of 0.0025 molar inhibits the germination of the spores. At a concentration of 0.0013 molar the spores germinate and produce microscopic mycelia, while at concentrations of 0.0006 molar or less, good growth is obtained.

Ferric nitrate in starch media is quite toxic to the spores of *Monilia*. In concentrations of 0.00027 molar or less, good growth was obtained, but in more concentrated media little or no growth occurred.

Silver nitrate is even more toxic than ferric nitrate; when its concentration was 0.00027 molar, the spores germinated, but produced only microscopic mycelia. In more concentrated media no germination took place.

Zinc nitrate in starch media is far more toxic than any of the other nitrates used; at a concentration of 0.000034 molar, it inhibited the germination of spores. In a concentration of 0.000025 molar, the spores germinated and produced microscopic mycelia, but when the zinc nitrate was used at a concentration of 0.000017 molar or less, abundant growth was obtained.

Ammonium tartrate is the only organic salt that was tried in these experiments. In starch media it is slightly more toxic than ammonium nitrate. In a concentration of 0.025 molar, the spores germinated but produced only microscopic mycelia, while in a like medium containing the same concentration of ammonium nitrate abundant growth was obtained.

As shown by TABLE I zinc nitrate is the most toxic substance used in starch media. If its limit concentration be taken as one then the limit concentrations of the other nitrates in the same medium may be expressed, by comparing equimolecular concentrations, approximately by the following numbers: silver nitrate, 5; ferric nitrate, 26; aluminum nitrate, 52; ammonium nitrate, 1,520; urea nitrate, 1,600; calcium nitrate, 16,560; and potassium nitrate, 53,200.

To show at a glance the relative toxic values of the various substances used, they are given in the order of their toxicity in TABLE II. That toxicity does not seem to be related to the valence of the kation is also shown by this table.

TABLE II

THE RELATIVE TOXICITY OF VARIOUS SALTS IN STARCH MEDIA

Valence of kation	Toxic concentration		Salt	
Monovalent	1.33	molar	potassium	nitrate
Divalent	.464	"	calcium	"
Monovalent	.400	"	sodium	"
Divalent	.156	"	barium	"
Monovalent	.040	"	urea	"
Monovalent	.038	"	ammonium	"
Monovalent	.025	"	ammonium	tartrate
Trivalent	.0013	"	aluminum	nitrate
Trivalent	.00067	"	ferric	"
Monovalent	.00013	"	silver	"
Divalent	.000025	"	zinc	"

The table shows, in the case of each salt, the greatest concentration at which growth was obtained when the salt was used

in starch media. A comparison of equimolecular concentrations shows that of all the nitrates used, potassium nitrate is the least toxic and zinc nitrate is the most toxic to *Monilia* when it is grown in a starch medium. Beginning with the least toxic, the order of toxicity of the nitrates in starch media is as follows: potassium nitrate, calcium nitrate, sodium nitrate, barium nitrate, urea nitrate, ammonium nitrate, aluminum nitrate, ferric nitrate, silver nitrate, and zinc nitrate. Having thus determined the degree of concentration at which the different nitrates are toxic to *Monilia sitophila* in starch media, experiments were made in which the organic part of the medium was varied for the purpose of determining whether or not the toxicity of these salts can be modified by the presence of one or another of the organic substances commonly used in making media. The organic substances tried are peptone, glucose, fructose, and galactose. The results obtained in these experiments are shown in TABLES III to VIII.

As shown by TABLE III, barium nitrate in peptone media at a concentration of 0.133 molar inhibits the germination of the spores of *Monilia*. In a starch medium containing barium nitrate at a concentration of 0.156 molar, the spores germinate and produce a small amount of mycelium. This shows that barium nitrate is more toxic in peptone media than in starch media. No concentration of barium nitrate shown in TABLE III was of sufficient strength to inhibit germination and growth in the presence of glucose. There was, however, a very small amount of mycelium in the media containing the barium nitrate at a concentration of 0.167 molar. This indicates that the toxic dose in glucose media is near the concentration 0.167 molar. The toxicity of barium nitrate in starch media and in glucose media is approximately the same. Its toxicity in peptone media is much greater than in glucose media or in starch media. In fructose media its toxicity is approximately the same as in starch and glucose media but is much less than in peptone media. At a concentration of 0.1 molar, barium nitrate in the presence of galactose inhibits the germination of spores. Its toxicity in galactose is approximately the same as in peptone, but is much greater than in starch, glucose, or fructose.

At a concentration of 0.033 molar, aluminum nitrate in peptone

TABLE III

THE TOXICITY OF BARIUM NITRATE IN PEPTONE, GLUCOSE, FRUCTOSE, AND GALACTOSE MEDIA

Medium									Growth after 11 days
.167 molar solution of barium nitrate	+	5%	peptone						0
.133 " " " " "	+	"	"						0
.067 " " " " "	+	"	"						−
.033 " " " " "	+	"	"						+
.017 " " " " "	+	"	"						+
.007 " " " " "	+	"	"						+
.167 " " " " "	+	"	glucose						−
.133 " " " " "	+	"	"						−
.100 " " " " "	+	"	"						−
.067 " " " " "	+	"	"						−
.033 " " " " "	+	"	"						−
.017 " " " " "	+	"	"						+
.007 " " " " "	+	"	"						+
.005 " " " " "	+	"	"						+
.004 " " " " "	+	"	"						+
.167 " " " " "	+	"	fructose						−
.133 " " " " "	+	"	"						−
.100 " " " " "	+	"	"						−
.067 " " " " "	+	"	"						−
.033 " " " " "	+	"	"						−
.017 " " " " "	+	"	"						−
.007 " " " " "	+	"	"						+
.005 " " " " "	+	"	"						+
.004 " " " " "	+	"	"						+
.167 " " " " "	+	"	"						0
.133 " " " " "	+	"	"						0
.100 " " " " "	+	"	"						0
.067 " " " " "	+	"	"						−
.033 " " " " "	+	"	"						−
.017 " " " " "	+	"	"						+
.007 " " " " "	+	"	"						+
.005 " " " " "	+	"	"						+
.004 " " " " "	+	"	"						+
distilled water	+	"	peptone						+
" "	+	"	glucose						+
" "	+	"	fructose						+
" "	+	"	galactose						+

media inhibits the germination of the spores; in a concentration of 0.017 molar, the spores germinate and produce microscopic mycelia. Aluminum nitrate in starch media is more than ten times as toxic as in peptone media. Its toxicity in glucose media is approximately the same as in starch media. It is much less

TABLE IV

THE TOXICITY OF ALUMINUM NITRATE IN PEPTONE, GLUCOSE, FRUCTOSE, AND GALACTOSE MEDIA

Medium									Growth after 11 days
.167	molar solution of aluminum nitrate					+	5%	peptone	0
.133	"	"	"	"	"	+	"	"	0
.100	"	"	"	"	"	+	"	"	0
.067	"	"	"	"	"	+	"	"	0
.033	"	"	"	"	"	+	"	"	0
.017	"	"	"	"	"	+	"	"	−
.007	"	"	"	"	"	+	"	"	+
.004	"	"	"	"	"	+	"	"	+
.167	"	"	"	"	"	+	"	glucose	0
.133	"	"	"	"	"	+	"	"	0
.100	"	"	"	"	"	+	"	"	0
.067	"	"	"	"	"	+	"	"	0
.033	"	"	"	"	"	+	"	"	0
.017	"	"	"	"	"	+	"	"	0
.006	"	"	"	"	"	+	"	"	0
.003	"	"	"	"	"	+	"	"	0
.0007	"	"	"	"	"	+	"	"	+
.167	"	"	"	"	"	+	"	fructose	0
.133	"	"	"	"	"	+	"	"	0
.100	"	"	"	"	"	+	"	"	0
.067	"	"	"	"	"	+	"	"	0
.033	"	"	"	"	"	+	"	"	0
.017	"	"	"	"	"	+	"	"	0
.007	"	"	"	"	"	+	"	"	0
.002	"	"	"	"	"	+	"	"	0
.001	"	"	"	"	"	+	"	"	0
.0007	"	"	"	"	"	+	"	"	−
.167	"	"	"	"	"	+	"	galactose	0
.133	"	"	"	"	"	+	"	"	0
.100	"	"	"	"	"	+	"	"	0
.067	"	"	"	"	"	+	"	"	0
.033	"	"	"	"	"	+	"	"	0
.017	"	"	"	"	"	+	"	"	0
.007	"	"	"	"	"	+	"	"	0
.004	"	"	"	"	"	+	"	"	0
.003	"	"	"	"	"	+	"	"	0
.001	"	"	"	"	"	+	"	"	−
.0007	"	"	"	"	"	+	"	"	+
			distilled	water		+	"	peptone	+
			"	"		+	"	glucose	+
			"	"		+	"	fructose	+
			"	"		+	"	galactose	+

toxic in peptone media than in glucose or starch media. It is less toxic in starch media and in peptone media than in glucose media and in fructose media. In galactose it is less toxic than in fructose. Barium nitrate, on the other hand, is much more toxic in galactose media than in fructose media.

TABLE V

THE TOXICITY OF FERRIC NITRATE IN PEPTONE, GLUCOSE, FRUCTOSE, AND GALACTOSE MEDIA

Medium			Growth after 11 days
.0067 molar solution of ferric nitrate	+ 5%	peptone	+
.0053 " " " " "	+ "	"	+
.0040 " " " " "	+ "	"	+
.0027 " " " " "	+ "	"	+
.0013 " " " " "	+ "	"	+
.0007 " " " " "	+ "	"	+
.0004 " " " " "	+ "	"	+
.0003 " " " " "	+ "	"	+
.0001 " " " " "	+ "	"	+
.0067 " " " " "	+ "	glucose	0
.0053 " " " " "	+ "	"	0
.0040 " " " " "	+ "	"	0
.0027 " " " " "	+ "	"	0
.0013 " " " " "	+ "	"	0
.0007 " " " " "	+ "	"	0
.0005 " " " " "	+ "	"	−
.0004 " " " " "	+ "	"	+
.0003 " " " " "	+ "	"	+
.0001 " " " " "	+ "	"	+
.0067 " " " " "	+ "	fructose	0
.0007 " " " " "	+ "	"	−
.0001 " " " " "	+ "	"	+
.0067 " " " " "	+ "	galactose	0
.0053 " " " " "	+ "	"	0
.0040 " " " " "	+ "	"	0
.0027 " " " " "	+ "	"	0
.0013 " " " " "	+ "	"	0
.0007 " " " " "	+ "	"	0
.0005 " " " " "	+ "	"	0
.0004 " " " " "	+ "	"	−
.0003 " " " " "	+ "	"	+
.0001 " " " " "	+ "	"	+
distilled water	+ "	peptone	+
" "	+ "	glucose	+
" "	+ "	fructose	+
" "	+ "	galactose	+

As shown by TABLE V, ferric nitrate at a concentration of 0.0067 molar, does not hinder the growth of *Monilia* in peptone media. In glucose media it inhibits the germination of the spores, when present at a concentration of 0.0007 molar. The small amount of mycelium obtained in fructose media containing ferric nitrate at a concentration of 0.0007 molar indicates that this is near its limit concentration in this medium. It is more toxic in galactose than in fructose media,—but is much less toxic in peptone than in any of the other media used.

TABLE VI

THE TOXICITY OF UREA NITRATE AND AMMONIUM NITRATE IN PEPTONE MEDIA

Medium		Growth after 11 days
.200 molar solution of urea nitrate	+ 5% peptone	−
.133 " " " " "	+ " "	+
.067 " " " " "	+ " "	+
.033 " " " " "	+ " "	+
.027 " " " " "	+ " "	+
.020 " " " " "	+ " "	+
.013 " " " " "	+ " "	+
.007 " " " " "	+ " "	+
.133 " " " ammonium tartrate	+ " "	0
.067 " " " " "	+ " "	0
.060 " " " " "	+ " "	0
.053 " " " " "	+ " "	0
.047 " " " " "	+ " "	0
.040 " " " " "	+ " "	0
.033 " " " " "	+ " "	0
.027 " " " " "	+ " "	−
.020 " " " " "	+ " "	−
.013 " " " " "	+ " "	−
.007 " " " " "	+ " "	+
distilled water	+ " "	+

The small amount of growth obtained in peptone media containing urea nitrate at a concentration of 0.2 molar indicates that this is approximately its limit concentration. In peptone media containing ammonium tartrate at a concentration of 0.027 molar, only microscopic mycelia were obtained. The toxicity of urea nitrate in starch media is four times as great as its toxicity in peptone media. The toxicity of ammonium tartrate, on the other hand, is approximately the same in starch as in peptone media.

TABLE VII

THE INFLUENCE OF PEPTONE ON THE TOXICITY OF FERRIC NITRATE IN STARCH MEDIA

Medium	Growth after 11 days
.0067 molar solution of ferric nitrate + 5% starch	0
.0067 " " " " " + " " + 1% peptone	0
.0067 " " " " " + " " + 2% "	−
.0067 " " " " " + " " + 3% "	−
.0067 " " " " " + " " + 4% "	+
.0067 " " " " " + " " + 5% "	+
.0067 " " " " " + " " + 6% "	+
.0067 " " " " " + " " + 7% "	+
.0067 " " " " " + " " + 8% "	+
.0067 " " " " " + " " + 9% "	+

TABLE shows the degree to which peptone counteracts the toxicity of ferric nitrate in starch media. When only 1 per cent of peptone was added to this medium none of the spores germinated; when 2 per cent of peptone was added the spores germinated and produced microscopic mycelia, but when 4 per cent of peptone was added vigorous growth was obtained.

TABLE VIII

THE TOXICITY OF VARIOUS SALTS IN SOME COMMON MEDIA

Toxic concentration	Salt	Medium
.156 molar	barium nitrate	starch
.067 "	" "	peptone
.167 "	" "	glucose
.167 "	" "	fructose
.067 "	" "	galactose
.0013 "	aluminum "	starch
.0170 "	" "	peptone
.0070 "	" "	glucose
.0007 "	" "	fructose
.0013 "	" "	galactose
.00067 "	ferric "	starch
.00670 "	" "	peptone
.00050 "	" "	glucose
.00070 "	" "	fructose
.00040 "	" "	galactose
.05 "	urea "	starch
.20 "	" "	peptone
.025 "	ammonium tartrate	starch
.027 "	" "	peptone

As shown by the above table, barium nitrate is more toxic in peptone and galactose than in the other media. Aluminum nitrate

and ferric nitrate, on the other hand, are far less toxic in peptone than in the other substances used. Urea nitrate is more toxic in starch media than in peptone media, while the toxicity of ammonium tartrate is the same in the two media.

DISCUSSION

My observations show beyond question that the concentration at which various inorganic salts are toxic to *Monilia sitophila* depends on the kind of organic substances contained in the media to which those salts are added. The same substance at a given concentration may be highly toxic in one medium but quite harmless in another. The concentration of ferric nitrate that inhibits the growth of *Monilia* in starch media has little or no effect upon its growth in peptone media. Lipman (3), using a peptone medium, found that calcium chloride is more toxic to *Bacillus subtilis* than is potassium chloride, sodium chloride, or magnesium chloride. My experiments suggest that he might have obtained a different result by adding these chlorides to a medium containing starch or sugar instead of peptone. Ssadikow (5) has tested the toxicity of strychnin salts to *Bacillus subtilis*, using as his media, bouillon, nutrient agar, and nutrient gelatin. He found this organism able to withstand a surprisingly high concentration of these salts. A very different result might have been obtained if the strychnin salts had been added to media lacking in peptone.

We have in such experiments, it seems to me, a means of attacking the whole question as to the nature of toxicity and toxic effects from an important and rather neglected standpoint and I hope to extend this work to a study of still other combinations of toxic and non-toxic substances as regards their effects on various living organisms. It is also obvious that such data are necessary to a proper understanding of the effects of various food substances, drugs, etc., both from the standpoint of the significance of the medium with which the chemical is combined when offered as a food and from the standpoint of its relation to the organic reserve and other substances which it meets in the cell.

SUMMARY

1. The degree of toxicity of barium nitrate, aluminum nitrate, ferric nitrate, and urea nitrate to *Monilia sitophila* depends on the organic substance contained in the media in which these salts are offered.

2. Barium nitrate is more toxic in peptone media than in starch media, while aluminum nitrate and ferric nitrate are more toxic in starch media than in peptone media.

3. Barium nitrate has practically the same toxicity in starch media that it has in either glucose or fructose media. Its toxicity in peptone media is the same as its toxicity in galactose media.

4. The toxicity of aluminum nitrate in galactose media is the same as its toxicity in starch media. Its toxicity in fructose is much greater than in peptone or glucose.

5. The toxicity of ferric nitrate is approximately the same in starch as in glucose, fructose, or galactose. Its toxicity in peptone, however, is much less than in any of the other substances used.

6. Urea nitrate is four times more toxic in starch media than in peptone media.

7. The toxicity of ammonium tartrate is practically the same in starch as in peptone media.

8. If the limit concentration of zinc nitrate in starch media be taken as 1, then the limit concentration of the other nitrates in the same kind of media may be expressed, by comparing equimolecular concentrations, approximately by the following numbers: silver nitrate, 5; ferric nitrate, 26; aluminum nitrate, 52; ammonium nitrate, 1,520; urea nitrate, 1,600; calcium nitrate, 16,560; and potassium nitrate, 53,200.

This work was done in the laboratories of the University of Missouri and under the direction of Dr. George M. Reed, to whom I am greatly indebted for encouragement and advice.

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Resistance of the prothallia of Camptosorus rhizophyllus to desiccation *

F. L. Pickett

Camptosorus rhizophyllus (L.) Link is found growing with mosses and lichens on the shaded surface of dry limestone ledges and on detached limestone slabs in open ravines and torrent beds. Only rarely have groups been found in well-shaded or continually moist places in this region (southern Indiana). Growing in places thus exposed without constant water supply, the plants are subjected to brief periods of abundant moisture (during and immediately after precipitation) which alternate with longer periods of drought. That plants with a delicate prothallial stage in their life history could secure and retain residence under such conditions has been a cause for surprise.

The drought-resisting power of some greenhouse cultures of this fern grown in the spring of 1912 suggested a possible adaptation to its well-known xerophytic habitat. In an attempt to determine to what extent this ability to withstand drought might be a factor in adaptation, fronds with mature spores were collected in October, 1912, and cultures were made as usual on sterilized soil in clay saucers. These cultures were subjected to a variety of conditions to be later enumerated.

An attempt was made to obtain information on the following points: the uniformity of spore germination and prothallial development, the ability of prothallia to resist or survive natural drought conditions, and the ability to survive conditions leading to complete desiccation.

Fronds were collected on October 26, 1912, and kept between sheets of filter paper in a book in the laboratory. The sporangia were lightly crushed to free the spores and then sown on thoroughly sterilized soil, November 22, 1912. The cultures were kept in the greenhouse and were protected by bell-jars supported on

* The writer has been unable to find any literature bearing upon this subject, for the prothallia of this or any other homosporous fern.

small blocks of wood to provide adequate ventilation. Some cultures were exposed to direct sunlight while others were exposed to strong diffused light only. The temperature conditions were the same, 20–25° C. The soil was kept moist, not wet, but was allowed to show a dry surface for a period of 12 to 24 hours once each week. The first green was noticed December 17, at which time the prothallia when examined with a microscope were found to be composed of two to ten cells each. These cultures showed good growth, seeming to suffer no injury from the dry periods. Those in the sunlight showed rather a more rapid development than those in diffused light. On February 11, 1913, the culture in sunlight contained prothallia in good condition but varying in size from merely germinated spores up to plants 2–3 mm. broad with but very few antheridia or archegonia. The culture in diffused light did not show similar prothallia until March 21, 1913.

The spores of *Camptosorus rhizophyllus* germinate very irregularly. Twelve weeks after the spores were sown, a small bit of soil—not over 3 mm. square—removed from a culture where the plants seemed most thrifty, showed all stages in development from spores with the perinium just ruptured to prothallia bearing mature antheridia and archegonia. Many spores retain their vitality up to May in the dry atmosphere of the laboratory, and fronds collected in March furnished viable spores for cultures. The long dormant period of spores on the moist soil of cultures suggests that they might remain so on the soil of their habitat through the winter season.

Four methods of reducing water content were used. First, a glycerin desiccator was used, consisting of two glass vials through which, by means of an aspirator, a current of air was drawn after passing through two U-tubes containing glycerin and crumpled filter paper. Heaviest c.p. glycerin was used. The aspirator was arranged so that the air of the vials was changed about one hundred times each twenty-four hours. Second, cultures were left under bell-jars, exposed to the warm air and full sunlight of the greenhouse. Third, cultures were left under bell-jars, exposed to the dry air and diffused light of the greenhouse lobby or vestibule at a slightly lower temperature, 16–20° C. This place represents as nearly as possible the natural growth

conditions. In the second and third cases full ventilation was secured by allowing the jars to rest on blocks of wood 2 cm. high. Fourth, large portions of a culture were placed in a desiccator over c.p. sulphuric acid and the whole apparatus was kept in a cool, moderately lighted location. In all cases, when soil and prothallia were removed from a dry chamber they were placed in contact with moist soil under a bell-jar subject to full diffused light at a temperature of 16–20° C., for recovery. Examination for dead prothallia was made after three or four days under such conditions. Extreme care was taken at all times when removing portions of cultures to or from the dry chambers, to leave the prothallia as far as possible undisturbed and uninjured.

Results—glycerin desiccator.—A large portion of the soil of a culture was removed to the vial of the desiccator and allowed to remain in the dry air undisturbed, except as small portions were removed for recovery and growth. Specimens placed in the desiccator on March 22 seemed to revive completely up to April 22, at which time a few small dead prothallia were found in a portion removed. Another portion removed April 29 showed about 50 per cent of the prothallia dead. The last of the soil and prothallia was removed May 5. All the smaller plants and all but a very few of the larger plants were dead at that time.

In this set of experiments a very few fully matured prothallia survived continuous exposure to dry air for forty-four days. Very few were damaged by such exposure for a period of thirty days. That the recovery was complete in case of survival is proven by the continued growth of the prothallia and their later production of sporophytes.

That vigorous desiccation follows immediately after the plants were placed in the vials is shown by the fact that the soil had given up all free moisture in twenty-four hours after being placed therein. As a check, at the beginning of this experiment a clump of thrifty mature prothallia of *Onoclea Struthiopteris* was placed in one of the vials. After forty-eight hours' exposure to the dry air not one plant recovered.

A similar set of experiments was arranged with the whole apparatus exposed to the direct sunlight. Most of the prothallia so exposed were dead at the end of twenty-eight days, and all were dead after thirty-five days of exposure.

Results—sulphuric acid desiccator.—A portion of soil bearing prothallia was removed to a porcelain dish in a desiccator containing c.p. sulphuric acid. The lid was sealed down with vaseline and the apparatus placed in diffused light at a temperature of 16–20° C. After eighteen hours the prothallia showed a marked yellowish color. A portion removed after four days showed a recovery of but two or three per cent. The plants removed at this time recovered very slowly, requiring a week to resume a normal appearance.

Results—normal dry air.—The soil mass of a culture was divided into two approximately equal parts and carefully removed to sterilized clay saucers. One portion was placed under a bell-jar exposed to the full sunlight in the greenhouse. The other was kept under a bell-jar exposed to full diffused light and at a temperature of 16–20° C., an average of four degrees lower than that for the first portion. After three weeks, but a few of the plants exposed to direct sunlight recovered, and all were dead after five weeks of such exposure. Of the second lot not exposed to direct sunlight a portion removed after thirty-four days showed almost complete recovery. After fifty-five days, about 25 per cent of the prothallia recovered. After sixty-three days, a very few of the largest plants recovered and continued to grow.

The conditions under which the second group of plants was kept approximate very closely the summer conditions in the regular habitat of *Camptosorus rhizophyllus*. The results of that set of experiments certainly suggest an explanation of this plant's abundant growth under such conditions. It should be noted here, as above, that full recovery of the plants has been demonstrated by their continued growth and later production of sporophytes. If mature prothallia can withstand continuous drought for two months, they would certainly survive the difficulties of the average season after late March, at which time spores may germinate outside. The occasional rains through the summer would make possible recovery, fertilization, and the production of sporophytes.

In connection with this set of experiments another should be noticed. A culture was prepared as for all the above on November 25, 1912. The drainage was such that a part of the soil

surface was dry at all times, except when occasionally flooded. The remaining portion was moist as in the other cultures. All gradations of moisture were in evidence in and between the two regions. Small prothallia were seen on December 18 on the damp soil. On March 1, 1913, most of the prothallia of this region showed mature sex organs. The drier portions at the latter date showed germinating spores, dwarf male prothallia, and later stages in development up to mature plants. After March 1, this culture was watered irregularly and was allowed to become quite dry each time before more water was applied. After April 15 the culture was screened from the direct sun. Water was occasionally applied so as to flood the whole surface. On May 5 there were many living prothallia and several young sporophytes. On June 9 there were several large, living prothallia and the young sporophytes were uninjured, although during the previous month the culture had been four times dry, once for seventy-two hours.

SUMMARY

As has been stated above, the experiment of subjecting prothallia to normal dry air without direct sunlight,—continuous conditions approximating the average of varying conditions found in nature,—has shown that the production of mature prothallia under such conditions is possible. The other experiments of subjecting prothallia to more thorough desiccation in the glycerin desiccator and over sulphuric acid show the possibility of surviving the extreme conditions found in nature. There can remain but little doubt that the drought-resisting character of the prothallia is a very effective factor in the adaptation of *Camptosorus rhizophyllus* to its habitat.

INDIANA UNIVERSITY, BLOOMINGTON

INDEX TO AMERICAN BOTANICAL LITERATURE

(1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Anthon, S. I. The surprise lily. Am. Bot. **19**: 81–83. Au 1913.
[Ilust.]
Calochortus macrocarpus.

Bailey, W. W. Transient botanizing. Am. Bot. **19**: 98, 99. Au 1913.

Bartholomew, E. T. Black heart of potatoes. Phytopathology **3**: 180–182. *pl. 19.* 14 Au 1913.

Bitter, G. *Solana* peruv., aequat., boliv. Bot. Jahrb. Beibl. **50**: 59–67. 19 Au 1913.
Includes 7 new species in *Solanum.*

Blodg tt, F. M. Hop mildew. Cornell Univ. Agr. Exp. Sta. Bull. 328: 281–310. *f. 93–1 1.* Mr 1913.
A disease caused by *Sphaerotheca Humuli.*

Börgesen, F. The marine algae of the Danish West Indies. Part I. *Chlorophyceae.* 1–160. *f. 1–126 + chart.* Copenhagen. 1913.
Includes *Pringsheima Udoteae, Cladophora uncinata, C. corallicola,* and *Avrainvillea Geppii,* spp. nov.

Brand, A. *Polemoniaceae* peruvianae et bolivienses. Bot. Jahrb. Beibl. **50**: 50–52. 19 Au 1913.
Includes *Huthia longiflora* sp. nov.

Brown, P. E. Media for the quantitative determination of bacteria in soils. Centralb. Bakt. Zweite Abt. **38**: 497–506. 9 Au 1913.

Burger, O. F. A bacterial rot of cucumbers. Phytopathology **3**: 169, 170. 14 Au 1913.

Clute, W. N. The day lilies. Am. Bot. **19**: 86–90. Au 1913. [Illust.]

Cogniaux, A. *Cucurbitaceae* andinae. Bot. Jahrb. Beibl. **50**: 75–76. 19 Au 1913.

Includes *Apodanthera eriocalyx* sp. nov.

Cogniaux, A. *Melastomataceae* peruvianae. II. Bot. Jahrb. Beibl. **50**: 31–33. 19 Au 1913.

Includes *Tibouchina fulvipilis* and *Axinaea Weberbaueri*, spp. nov.

Collins, F. S. Three plants with extension of range. Rhodora **15**: 169, 170. 1 S 1913.

Panicum Bicknellii, *Potentilla tridentata*, and *Juncus bufonius var. halophilus*.

Collins, G. N. Mosaic coherence of characters in seeds of maize. U. S. Dept. Agr. Plant Ind. Circ. 132: 19–21. 19 Je 1913.

Cook, M. T., & Schwarze, C. A. A *Botrytis* disease of dahlias. Phytopathology **3**: 171–173. *pl. 17*. 14 Au 1913.

Dammer, U. *Solanaceae* americanae. II. Bot. Jahrb. Beibl. **50**: 52–58. 19 Au 1913.

Includes 6 new species in *Dunalia*.

Fawcett, H. S. Two fungi as casual agents in gummosis of lemon trees in California. Phytopathology **3**: 194, 195. Je 1913. Also published in Monthly Bull. State Comm. Hort. Calif. **2**: 601–617. *f. 340–351*. Au 1913.

Botrytis vulgaris and *Pythiacystis citrophthora*.

Fernald, M. L. A peculiar variety of the canoe birch. Rhodora **15**: 168, 169. 1 S 1913.

Ferry, R. Étude sur les Amanites. Premier Supplément Rev. Myc. **1911**: 1–96. *pl. 1–8*. 14 Je 1911.

Fletcher, E. F. Further wool-waste plants at Westford, Massachusetts. Rhodora **15**: 172. 1 S 1913.

Fromme, F. D. The culture of cereal rusts in the greenhouse. Bull. Torrey Club **40**: 501–521. 10 S 1913.

Geckler, A. *Echinocactus Droegeanus* Hildm. Monats. Kakteenk. **23**: 122. 15 Au 1913.

Gilg, E. *Gentianaceae* andinae. Bot. Jahrb. Beibl. **50**: 48–50. 19 Au 1913.

Includes five new species in *Gentiana* and one in *Macrocarpaea*.

Gilg, E. *Malesherbiaceae* andinae. II. Bot. Jahrb. Beibl. **50**: 11, 12. 19 Au 1913.

Includes *Malesherbia Weberbaueri* and *M. scarlatiflora*, spp. nov.

Griggs, R. F. Observations on the geographical composition of the Sugar Grove flora. Bull. Torrey Club **40**: 487–499. *f. 1–10.* 10 S 1913.

Güssow, H. T. The barberry and its relation to black rust of grain. Phytopathology **3**: 178, 179. 14 Au 1913.

Harris, J. A. An illustration of the influence of substratum heterogeneity upon experimental results. Science II. **38**: 345, 346. 5 S 1913.

Harter, L. L., & Field, E. C. A dry rot of sweet potatoes caused by *Diaporthe Batatatis.* U. S. Dept. Agr. Plant Ind. Bull. 281: 7–38. *pl. 1–4+f. 1–4.* 1 My 1913.

Heribert-Nilsson, N. *Oenothera*-problemet. Svensk Bot. Tidsk. **7**: 1–16. 25 Mr 1913. [Illust.]

Herter, W. José Arechavaleta. Monats. Kakteenk. **23**: 125–127. 15 Au 1913.

Hill, G. R. Respiration of fruits and growing plant tissues in certain gases, with reference to ventilation and fruit storage. Cornell Univ. Agr. Exp. Sta. Bull. 330: 377–408. Ap 1913.

Hull, E. D. Advance of *Potamogeton crispus* L. Rhodora **15**: 171, 172. 1 S 1913.

Johnston, J. R. The nature of fungous diseases of plants. Porto Rico Sugar Producers' Assoc. Circ. 2: 3–25. *f. 1–9.* My 1913.

Jostmann, A. *Pilocereus lanatus* (H. B. K.) Web. var. *Haagei* (Poselg.) Schelle. Monats. Kakteenk. **23**: 125. 15 Au 1913. [Illust.]

Kellerman, K. F. The use of congo red in culture media. U. S. Dept. Agr. Plant Ind. Circ. 130: 15–17. 21 Je 1913.

Keyser, A. Variation studies in brome grass. (A preliminary report). Colorado Agr. Exp. Sta. Bull. 190: 3–20. *pl. 1–19.* Je 1913.

Kränzlin, F. *Amaryllidaceae* peruvianae, bolivienses, brasilienses. Bot. Jahrb. Beibl. **50**: 2–5. 19 Au 1913.

Includes *Collania Herzogiana, Bomarea Ulei, B. Loreti,* and *Eucharis Ulei,* spp. nov.

Kränzlin, F. *Buddleiae* americanae nonullis gerontogaeis adjectis. Bot. Jahrb. Beibl. **50**: 33–47. 19 Au 1913.

Includes 22 new species in *Buddleia.*

Kränzlin, F. *Calceolariae* peruv., aequat., argent. Bot. Jahrb. Beibl. **50**: 67–75. 19 Au 1913.

Includes 9 new species in *Calceolaria.*

Loesner, T. *Celastraceae* andinae. II. Bot. Jahrb. Beibl. **50**: 8–10. 19 Au 1913.

Includes *Maytenus apurimacensis* and *M. andicola,* spp. nov.

Meinecke, E. P. Notes on *Cronartium coleosporioides* Arthur and *Cronartium filamentosum*. Phytopathology **3**: 167, 168. 14 Au 1913.

Morse, W. J. Some borrowed ideas in laboratory equipment. Phytopathology **3**: 175–177. *pl. 18.* 14 Au 1913.

Muschler, R. *Caryophyllacea* aequatoriana. Bot. Jahrb. Beibl. **50**: 5, 6. 19 Au 1913.

***Drymaria adiantoides* sp. nov.**

Muschler, R. *Compositae* peruv. et boliv. II. Bot. Jahrb. Beibl. **50**: 76–108. 19 Au 1913.

Includes 29 new species in *Mikania* (1), *Liabum* (9), *Gynoxis* (6), *Chuquiraga* (3), *Onoseris* (4), *Barnadesia* (5), *Mutisia* (3), and *Jungia* (3).

Muschler, R. *Crucifera* peruviana. Bot. Jahrb. Beibl. **50**: 7, 8. 19 Au 1913.

***Cremolobus stenophyllus* sp. nov.**

Orton W. A. International phytopathology and quarantine legislation. Phytopathology **3**: 144–151. 14 Au 1913.

Pilger, R. Biologie und Systematik von *Plantago* § *Novorbis*. Bot. Jahrb. **50**: 171–287. *f. 1–30.* 19 Au 1913.

Includes *Plantago taraxacoides, P. hypoleuca, P. pseudomyosuros, P. chubutensis, P. ecuadorensis, P. Berroi, P. achalensis, P. Buchtienii, P. macropus, P. Niederleinii, P. Arechavaletai, P. ventanensis, P. denudata, P. valida*, spp. nov., and many new varieties from America.

Pilger, R. *Graminea* peruviana. Bot. Jahrb. Beibl. **50**: 1, 2. 19 Au 1913.

***Trichoneura Weberbaueri* sp. nov.**

Pilger, R. *Rosacea* peruviana. Bot. Jahrb. Beibl. **50**: 8. 19 Au 1913.

***Prunus huantensis* sp. nov.**

Prescott, A. The moonwort. Am. Bot. **19**: 95–97. Au 1913. [Illust.]

Putnam, B. L. Our native *Aquilegia*. Am. Bot. **19**: 97. Au 1913.

Rydberg, P. A. Studies on the Rocky Mountain flora—XXIX. Bull. Torrey Club **40**: 461–485. 10 S 1913.

Includes 26 new species in *Hypopitys* (1), *Primula* (1), *Androsace* (2), *Amarella* (1), *Hydrophyllum* (1), *Anthopogon* (1), *Dasystephana* (2), *Amsonia* (1), *Cressa* (1), *Cuscuta* (1), *Gilia* (5), *Leptodactylon* (1), *Polemonium* (2), *Phacelia* (1), *Oreocarya* (2), *Pentstemon* (1), *Mimulus* (1), and *Castilleja* (1).

Saunders, C. F. Wild soaps. Am. Bot. **19**: 99, 100. Au 1913.

Schellenberg, G. *Berberidacea* peruviana. Bot. Jahrb. Beibl. **50**: 6, 7. 19 Au 1913.

***Berberis peruviana* sp. nov.**

Schellenberg, G. *Frankeniacea* peruviana. Bot. Jahrb. Beibl. **50**: 10, 11. 19 Au 1913.
***Frankenia peruviana* sp. nov.**

Shear, C. L. The type of *Sphaeria radicalis* Schw. Phytopathology **3**: 191, 192. 14 Au 1913.

Stewart, V. B. The fire blight disease in nursery stock. Cornell Univ. Agr. Exp. Sta. Bull. 329: 317–371. *f. 112–126.* Ap 1913.

Sturgis, W. C. *Herpotrichia* and *Neopeckia* on conifers. Phytopathology **3**: 152–158. *pl. 12, 13.* Je 1913.

Swingle, W. T. *Feroniella*, genre nouveau de la tribu des *Citreae*, fondé sur le *F. oblata*, espèce nouvelle de l'Indo-Chine. Bull. Soc. Bot. France **59**: 774–783. *pl. 18.* 18 F 1912.

Sydow, H. & P. Novae fungorum species—X. Ann. Myc. **11**: 254–271. *f. 1–8.* Je 1913.
Includes *Sphaerulina salicina* from North Dakota, *Phyllachora atro-maculans* and *Dothidella Picramniae* from Costa Rica.

Taubenhaus, J. J. The black rots of the sweet potato. Phytopathology **3**: 159–166. *pl. 14–16.* Au 1, 13.
Includes *Sclerotium bataticola* sp. nov.

Thomson, R. B. On the comparative anatomy and affinities of the *Araucarineae.* Philos. Trans. Royal Soc. London B **204**: 1–50. *pl. 1–7.* 7 My 1913.

Trelease, W. *Furcraea* peruviana. Bot. Jahrb. Beibl. **50**: 5. 19 Au 1913.
***Furcraea occidentalis* sp. nov.**

Tullsen, H. *Pentstemon grandiflorus.* Am. Bot. **19**: 84, 85. Au 1913. [Illust.]

Urban, I. Plantae novae andinae imprimis Weberbaurinae. VI. Bot. Jahrb. Beibl. **50**: 1–108. 19 Au 1913.
Consists of 19 separate papers here indexed under their respective authors: Bitter, Brand, Cogniaux, Dammer, Gilg, Kränzlin, Loesener, Muschler, Pilger, Schellenberg, Trelease, and Vaupel.

Vaupel, F. *Cactaceae* andinae. Bot. Jahrb. Beibl. **50**: 12–31. 19 Au 1913.
Includes ***Cephalocereus melanostele, Cereus acanthurus, C. apiciflorus, C. brachypetalus, C. decumbens, C. micranthus, C. plagiostoma, C. squarrosus, C. Weberbauri, Echinocactus aurantiacus, E. molendensis, E. myriacanthus, E. Weberbaueri, Opuntia dactylifera*, and *O. ignescens*, spp. nov.**

Vaupel, F. Sieben neue *Cactaceae.* Monats. Kakteenk. **23**: 105–107. 15 Jl 1913.

Vaupel, F. Verzeichnis der seit der Herausgabe des I. Nachtrages zu K.

Schumann's "Gesamtbeschreibung der Kakteen" (1903) neu beschriebenen und umbenannten Gattungen und Arten aus der Familie der *Cactaceae*. Monats. Kakteenk. **23**: 11–14. 15 Ja 1913; 23–27. 15 F 1913; 37–41. 15 Mr 1913; 56–60. 15 Ap 1913; 72–78. 15 My 1913; 81–88. 15 Je 1913.

Weingart, W. *Cereus Hirschtianus* K. Schum. Monats. Kakteenk. **23**: 108–111. 15 Jl 1913.

Weir, J. R. *Auricularia mesenterica* (Dicks.) Pers. Phytopathology **3**: 192. Au 1913.

Wellington, R. Mendelian inheritance of epidermal characters in the fruit of *Cucumis sativus*. Science II. **38**: 61. 11 Jl 1913.

Wernham, H. F. New *Rubiaceae* from tropical America—II. Jour. Bot. **51**: 218–221. Jl 1913.

Includes eleven new species in *Pteridocalyx* (1), *Tournefortiopsis* (1), *Gonzalea* (4), *Machaonia* (3), *Malanea* (1), and *Cephaelis* (1).

Wester, P. J. Annonaceous possibilities for the plant breeder. Philip. Agr. Rev. **6**: 312–321. *pl. 2–7*. Jl 1913.

Westling, R. Über die grünen Spezies der Gattung *Penicillium*. Arkiv Bot. **11**[1]: 1–156. *f. 1–81*. 1911.

Discusses several American species.

Williams, R. S. *Dicranaceae*. N. Am. Fl. **15**: 77–158. 8 Au 1913.

Includes new species in *Dicranella* (2), *Dicranum* (1), and *Campylopus* (4).

Williams, R. S. *Leucobryaceae*. N. Am. Fl. **15**: 159–166. 8 Au 1913.

Includes *Octoblepharum erectifolium* Mitten sp. nov.

Wilson, G. W. *Fusarium* or *Verticillium* on okra in North Carolina? Phytopathology **3**: 183–185. Je 1913.

Wolf, F. A. Melanose. Phytopathology **3**: 190, 191. 14 Au 1913.

Yamanouchi, S. The life history of *Zanardinia*. Bot. Gaz. **56**: 1–35. *pl. 1–4+f. 1–24*. 16 Jl 1913.

York, H. H. The origin and development of the embryo sac and embryo of *Dendrophthora opuntioides* and *D. gracile*[*is*]. I. Bot. Gaz. **56**: 89–111. *pl. 5, 6 + f. 1, 7, 8, 12a, 20, 21*. 14 Au 1913; II. Bot. Gaz. **56**: 200–216. *pl. 7*. 17 S 1913.

Vol. 40 No. 12

BULLETIN

OF THE

TORREY BOTANICAL CLUB

DECEMBER, 1913

West Indian mosses—I

ELIZABETH GERTRUDE BRITTON

(WITH PLATE 25)

A. WEST INDIAN MOSSES KNOWN TO LINNAEUS

In Linnaeus' Species Plantarum* 8 genera† and 103 species of mosses are recognized, of which only 2 are known to be tropical American in their distribution, ranging from southern Florida to South America. The first of these tropical species is *Bryum albidum* L. (p. 1118) known to Dillenius‡ as *Bryum nanum, lariginis foliis albis*, and now known as *Octoblepharum albidum* (L.) Hedw., with the type locality on the island of New Providence in the Bahamas.

The other species, *Rhizogonium spiniforme* (L.) Bruch was the first species of *Hypnum* named by Linnaeus and it also was based on a Dillenian description and plate.§ He called it "the *Herring's-Bone Hypnum*" and his specimens were sent to him from Mt. Diabolo, Jamaica, by Sir Hans Sloane. Its range through the tropics is even wider than that of *Octoblepharum*, including the Islands of the Pacific; both species are known to occur not only throughout the American tropics but also in Asia and Africa.

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* 1106–1130. 1753.

† 1. *Sphagnum*..... 2
2. *Phascum*..... 3
3. *Fontinalis*..... 4
4. *Splachnum*..... 3
5. *Polytrichum*..... 3
6. *Mnium*..... 18
7. *Bryum*..... 30
8. *Hypnum*..... 40
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‡ Historia Muscorum 364. *pl. 46. f. 21.* 1741.

§ Historia Muscorum 332. *pl. 43. f. 68.* 1741.

[The BULLETIN for November (**40**: 599–652. *portrait*) was issued 24 N 1913.]

1. OCTOBLEPHARUM ALBIDUM (L.) Hedw. Descr. 3: 15. 1791

Bryum albidum L. Sp. Pl. 1118. 1753.

TYPE LOCALITY: New Providence, Bahamas.

DISTRIBUTION: Florida and the Bahamas, throughout the West Indies; in Cuba, Jamaica, Haiti and St. Domingo, Porto Rico, Dominica, St. Thomas, St. Kitts, Montserrat, Guadeloupe, Martinique, St. Lucia, Grenada to Trinidad; also in South America and tropical regions of Africa and Asia.

ILLUSTRATIONS: Dill. Hist. Musc. *pl. 46. f. 21;* Hedw. Descr. 3: *pl. 6A;* Card. Rech. Anat. Leuc. *pl. 12. f. 61.*

EXSICCATAE: Sull. Musci Cub. Wright. *55.* 1861; Husnot, Pl. Ant. Fr. *121.* 1868; Austin, Musci App. Suppl. *478.* 1874: Ren. & Card. Musci Am. Sept. Exsicc. *213;* Holz. Musci Acroc. Bor. Am. *57;* Small, Mosses S. U. S. *52.*

2. RHIZOGONIUM SPINIFORME (L.) Bruch, Flora 29: 134. 1846

Hypnum spinaeforme L. Sp. Pl. 1122. 1753.

Mnium spiniforme C. Müll. Syn 1: 175. 1849.

TYPE LOCALITY: Mt. Diabolo, Jamaica, *Hans Sloane.*

DISTRIBUTION: In wet woods, in tropical regions of all portions of the world. Southern United States: Georgia, Alabama, Louisiana, Florida; Jamaica, Cuba, Haiti, Porto Rico, Guadeloupe to S. America: Mexico, Guatemala, Costa Rica, and Panama.

ILLUSTRATIONS: Sloane, Hist. Jam. *pl. 25. f. 4.* 1707; Dill. Hist. Musc. 332. *pl. 43. f. 8.* 1741.

EXSICCATAE: Sull. Musci Cub. Wright. *58.* 1861; Husnot, Pl. Ant. Fr. *152.* 1868; Austin, Musci App. Suppl. *516.* 1874; Ren. & Card. Musci Am. Sept. Exs. *64;* Holz. Musc. Acroc. Bor. Am. *174;* Pringle, Musci Mex. *10482.*

Another of the Linnaean species, *Hypnum cuspidatum* L., has been found in the high mountains of Jamaica. *Pogonatum urnigerum* L. Sp. Pl. 1109. 1753, was also credited to Jamaica, following Dillenius, who quotes Hans Sloane's History of Jamaica and mistook his *f. 5, pl. 25,* for this European species. *F. 4* of the same plate is unmistakable for *Rhizogonium spiniforme.*

B. WEST INDIAN MOSSES KNOWN TO OLOF SWARTZ

In his Prodromus, Swartz* retained 5 of the generic names

* Olof Swartz, Nova Genera & Species Plantarum seu Prodromus, etc. 138–142. 1788.

used by Linnaeus* and enumerated 41 species, which as at present recognized belong to 37 different genera, three of these having their type localities in Hispaniola (Haiti and Santo Domingo), all the rest in Jamaica.

In studying the collections made by Mr. Wm. Harris in Jamaica and our own later collections, a special effort has been made to obtain an accurate knowledge of these Swartz types and Dr. A. Le Roy Andrews, of Cornell University, very kindly consented, when he visited Stockholm in the summer of 1912, to examine these types for me and compare them with specimens from our own collections in Jamaica, sent as duplicates to the Naturhistoriska Riksmuseum. Dr. Andrews was able to see and compare the original specimens with ours in all but two cases: *Bryum parasiticum* Sw. [= *Syrrhopodon parasiticus* (Sw.) Besch.] and *Hypnum congestum* Sw. [= *Pleuropus congestus* (Sw.) Broth.], which species we have not yet been able to recognize, the former being from Hispaniola and the type lacking in Swartz' herbarium, the latter from Jamaica and Haiti. We suspect from the illustration given by Hedwig that the latter is probably referable to *Palamocladium Bonplandi* (Hook.) Broth., which Brotherus later refers to *Pleuropus*, though he states that he has not seen specimens of *Pleuropus congestus*.

In 1806 Swartz discarded his Linnaean limitations† and adopted some of the generic changes proposed by Hedwig (1792), to whom he sent specimens of most of his West Indian mosses, from which almost all of Hedwig's plates were drawn. This eliminated *Fontinalis* and *Mnium* from the West Indies and added seven genera‡ and three species to the list given in the Prodromus; he further amplified his list by giving more in detail the stations and habitats. These are translated and quoted in the following list of species in the sequence enumerated by Swartz, with their modern names, synonyms, and distribution as at present known to us from the West Indies:

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* *Fontinalis, Polytrichum, Mnium, Bryum*, and *Hypnum*.

† Fl. Ind. Occ. 3: 1759–1841. 1806.

‡ *Encalypta, Trichostomum, Tortula, Dicranum, Pterogonium, Neckera*, and *Leskea*.

1. **Neckera jamaicense** (Gmel.) E. G. Britton, comb. nov.

Fontinalis crispa Sw. Prod. 138. 1788. Not *Hypnum crispum* L. Sp. Pl. 1124. 1753.

Hypnum jamaicense Gmel. Syst. Nat. 2: 1341. 1791.

Neckera undulata Hedw. Descr. 3: 51. 1792.

Neckera undulata Hedw.; Sw. Fl. Ind. Occ. 3: 1780. 1806.

Neckeropsis undulata Kindb. Eu. & N. A. Bryin. 1: 20. 1897.

HABITAT AND TYPE LOCALITY: "On trunks of trees in dense low woods, Jamaica."

DISTRIBUTION: Not uncommon on trees from Florida and the Greater and Lesser Antilles to Trinidad; Mexico, Guatemala, and Panama; also in South America.

ILLUSTRATIONS: Dill. Hist. Musc. 294. *pl. 32. f. 8;* Hedw. Descr. *pl. 21* (from Swartz' type).

EXSICCATAE: Austin, Musci App. Suppl. *529;* Sull. Musci Cub. Wright. *75;* Husnot, Pl. Ant. Fr. *155;* Grout, N. A. Musci Pleur. *230.*

2. NECKERA DISTICHA (Sw.) Hedw. Descr. 3: 53. 1792

Fontinalis disticha Sw. Prod. 138. 1788.

Neckera disticha Hedw. Descr. 3: 53. 1792.

Neckera disticha Sw. Fl. Ind. Occ. 3: 1784. 1806.

Neckeropsis disticha Kindb. Eu. & N. A. Bryin. 1: 20. 1897.

HABITAT AND TYPE LOCALITY: On trunks of trees, Jamaica and Hispaniola.

DISTRIBUTION: Less common, on trees. Florida and the Greater and Lesser Antilles to South America; in Central America from Mexico to Panama; also in Africa.

ILLUSTRATION: Hedw. Descr. *pl. 22* (from Swartz' type).

EXSICCATAE: Austin, Musci App. Suppl. *530.*

3. PTEROBRYUM FILICINUM (Sw.) Mitt. Jour. Linn. Soc. 12: 425. 1869

Fontinalis filicina Sw. Prod. 138. 1788.

Neckera filicina Hedw. Descr. 3: 45. 1792.

Pilotrichum filicinum P. Beauv. Prod. 83. 1805.

Neckera filicina Sw. Fl. Ind. Occ. 3: 1788. 1806.

Pireella filicina Cardot, Rev. Bryol. 40: 18. 1913.

HABITAT AND TYPE LOCALITY: "Near Coldspring, high mountains of southern Jamaica, on trunks of trees."

DISTRIBUTION: Jamaica and Cuba.

ILLUSTRATION: Hedw. Descr. *pl. 18* (from Swartz' type).

EXSICCATAE: Sull. Musci Cub. Wright. *76*.

This species has immersed capsules and seems to belong where Mitten has placed it.

4. PILOTRICHUM HYPNOIDES (Sw.) P. Beauv. Prod. 83. 1805

Fontinalis hypnoides Sw. Prod. 138. 1788.

Neckera hypnoidea Hedw. Descr. 3: 43. 1792.

Neckera hypnoides Sw. Fl. Ind. Occ. 3: 1790. 1806.

HABITAT AND TYPE LOCALITY: "Jamaica, on trunks of trees in high mountains."

DISTRIBUTION: Jamaica to Trinidad.

ILLUSTRATION: Hedw. Descr. *pl. 17* (from Swartz' type).

5. CRYPHAEA FILIFORMIS (Sw.) Brid. Bryol. Univ. 2: 251. 1827

Fontinalis filiformis Sw. Prod. 138. 1788.

Neckera filiformis Hedw. Descr. 3: 41. 1792.

Neckera filiformis Sw. Fl. Ind. Occ. 3: 1786. 1806.

HABITAT AND TYPE LOCALITY: "Hispaniola, in arid regions on branches of *Haematoxylon campechianum*."

DISTRIBUTION: Jamaica, Cuba, and Santo Domingo; also in South America, Central America and Mexico (Guatemala and Yucatan).

ILLUSTRATION: Hedw. Descr. *pl. 16* (from Swartz' type).

EXSICCATAE: Sull. Musci Cub. Wright. *67*.

6. POGONATUM TORTILE (Sw.) Brid. Bryol. Univ. 2: 108. 1827

Polytrichum convolutum Sw. Prod. 139. 1788. Not L. 1753.

Polytrichum convolutum Hedw. Sp. Musc. 94. 1801.

Pogonatum convolutum Beauv. Prod. 85. 1805.

Polytrichum tortile Sw. Fl. Ind. Occ. 3: 1839. 1806.

Polytrichum domingense Brid. Mant. 201. 1819.

Polytrichum cubense Sull. Proc. Am. Acad. 5: 281. 1861.

Polytrichum glaucinum Besch. Ann. Sci. Nat. VI. 3: 210. 1876.

Polytrichum Husnotianum Besch. l. c.

Polytrichum crispulum Besch. l. c. 211.

Polytrichum laxifolium Besch. l. c. 211.
Polytrichum Pleeanum Besch. l. c. 212.
Polytrichum Sintenisii C. Müll. Hedwigia 37: 222. 1898.
Polytrichum (Catharinella) obscuro-viridis C. Müll. Hedwigia 37: 223. 1898.

HABITAT AND TYPE LOCALITY: "On clay banks, high mountains of southern Jamaica."

DISTRIBUTION: Cuba, Jamaica, Haiti, Porto Rico, Guadeloupe, Martinique, Dominica, Grenada, and Barbados.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 20.*

EXSICCATAE: Sull. Musci Cub. Wright. *57;* Husnot, Pl. Ant. Fr. *153.*

This species varies greatly according to habitat, whether dry or wet, sunny or shady. It usually grows on roadside banks of the hard red clay, on the dry or southern sides of the West Indian islands and under such conditions, does not attain the lax, long leaves that are produced in shady moist valleys. Microscopic sections of the leaves show the lamellae to be somewhat variable but all of one generally uniform character, and though the serrations of the margins are more or less variable, the teeth being at times appressed and at others spreading, we find no constant differences between them. The presence of teeth on the back of the costa is just as true of *P. tortile* Sw. as of *P. glaucinum* Besch.

7. BREUTELIA TOMENTOSA (Sw.) Sch. "In Hb." Paris, Index Bryol. 1: ed. 2. 173. 1904

Mnium tomentosum Sw. Prod. 139. 1788.
Bryum tomentosum Sw. Fl. Ind. Occ. 3: 1837. 1806.
Bartramia macrocarpa Hampe, Linnaea 32: 141. 1863.
Bartramia macrotheca Hampe, Ann. Sci. Nat. V. 3: 373. 1866.
Breutelia macrotheca Jaeg. Adumb. 1: 556. 1873–74.

HABITAT AND TYPE LOCALITY: " On the edge of woods high mountains of Jamaica."

DISTRIBUTION: Jamaica and Guadeloupe to South America; also Mexico and Costa Rica.

ILLUSTRATIONS: Hooker, Musci Exot. *pl. 19.* 1818. From original specimen of Swartz. E. & P. Nat. Pfl. 1^3: 656. *f. 498.* 1904.

8. PHILONOTIS SPHAERICARPA (Sw.) Brid. Bryol. Univ. 2: 25. 1827

Mnium sphaericarpon Sw. Prod. 139. 1788.
Mnium sphaericarpum Hedw. Descr. 3: 93. 1792.
Bryum sphaericarpon Sw. Fl. Ind. Occ. 3: 1835. 1806.
Bartramia sphaericarpa Mitt. Jour. Linn. Soc. 12: 261. 1869.

HABITAT AND TYPE LOCALITY: "In shady mossy places, summits of mountains of southern Jamaica."

DISTRIBUTION: Florida, Jamaica, Porto Rico, St. Thomas, St. Kitts, St. Vincent, Martinique, and Guadeloupe; Honduras to South America.

ILLUSTRATION: Hedw. Descr. 3: *pl. 38A*.

9. DITRICHUM RUFESCENS (Hampe) Broth. in E. & P. Nat. Pfl. 1^3: 300. 1901

Mnium strictum Sw. Prodr. 139. 1788. Not *Ditrichum strictum* Hampe. 1867.
Trichostomum strictum Sw. Fl. Ind. Occ. 3: 1761. 1806.
Trichostomum pallidum strictum Schwaegr. Suppl. 2^1: 77. 1823.
Leptotrichum rufescens Hampe, Linnaea 31: 521. 1862.
Cynontodium strictum Mitt. Jour. Linn. Soc. 12: 42. 1869.
Cynontodium rufescens Mitt. Jour. Linn. Soc. 12: 44. 1869.
Leptotrichum mexicanum Sch.; Besch. Mém. Soc. Sci. Nat. Cherbourg 16: 174. 1872.
Leptotrichum capillifolium Sch.; Jaeg. Adumb. 1: 388. 1871–72.
Leptotrichum pseudo-rufescens C. Müll. Bull. Herb. Boiss. 5: 554. 1897.

HABITAT AND TYPE LOCALITY: "Jamaica, on shady slopes in sandy wet soil among other mosses, cold places."

DISTRIBUTION: Jamaica, 1,500–2,100 meters. Also, Mexico to Colombia.

ILLUSTRATION: Schwaegr. Suppl. *pl. 123*.

10. TORTULA AGRARIA (Sw.) Sw. Fl. Ind. Occ. 3: 1763. 1806

Bryum agrarium Sw. Prod. 139. 1788.
Bryum acuminatum Sw. Prod. 139. 1788.
Barbula agraria Hedw. Descr. 3: 17. 1792.
Barbula Raui Aust. Bull. Torrey Club 6: 43. 1875.

HABITAT AND TYPE LOCALITY: "Jamaica and Hispaniola, in sugar fields and on calcareous rocks."

DISTRIBUTION: Florida and Texas. Common in the Bahamas on limestone rocks, whence it was known to Dillenius. Jamaica, Cuba, Porto Rico, Guadeloupe, Antigua, Montserrat to Trinidad and South America; also in Mexico.

ILLUSTRATION: Hedw. Descr. *pl. 6B*, from original specimens collected by Swartz in Jamaica and Santo Domingo.

11. BRYUM ACUMINATUM Sw. Prod. 139. 1788.

(See 10)

12. SYRRHOPODON LYCOPODIOIDES (Sw.) C. Müll. Syn. 1: 538. 1849

Bryum lycopodioides Sw. Prod. 139. 1788.
Dicranum? lycopodioides Sw. Fl. Ind. Occ. 3: 1766. 1806.

HABITAT AND TYPE LOCALITY: "Jamaica; in moist shady woods, on high mountains."

DISTRIBUTION: Jamaica, Santo Domingo, Haiti, Porto Rico, Guadeloupe, and Martinique to Trinidad.

EXSICCATAE: Husnot, Pl. Ant. Fr. *151*.

13. SYRRHOPODON PARASITICUS Besch. Ann. Sci. Nat. VIII. 1: 298. 1895

Bryum parasiticum Sw. Prod. 139. 1788.
Encalypta parasitica Sw. Fl. Ind. Occ. 3: 1759. 1806.
Calymperes parasitica Hook. & Grev. Edinb. Jour. Sci. 1: 131. 1824.

The type cannot be found at Stockholm in Swartz' herbarium. A fragment of the type specimen exists at Kew, and Mitten had only two leaves of it. He states that it is very close to *Calymperes Richardi* but the illustration given by Schwaegrichen of the calyptra and the description given by Swartz, "*Calyptra longa subulata, non laxa, pallida, ore aequali, latere demum fissili*" disprove this, and it is evident, either that Schwaegrichen was mistaken in figuring a calyptra which resembles that of a *Macromitrium* or it is a species of that genus, which is very common in Jamaica. Mitten referred a specimen collected by R. Spruce in South America (no. 2) to this species but that proves to be a true *Calymperes*.

The duplicate type from which Schwaegrichen's plate was drawn has been loaned to us from Geneva and corresponds with all of this plate except the calyptra, which is lacking; but the hyaline basal cells are not clearly indicated. It is evidently a species of *Syrrhopodon* with entire leaf margins bordered by elongated cells and does not agree with any known to us thus far from the West Indies.

HABITAT AND TYPE LOCALITY: Hispaniola. "On branches of *Haematoxylon* and *Mimosa Unguis-cati*."

DISTRIBUTION: Known only from the original collection.

ILLUSTRATION: Schwaegr. Suppl. 1: 60. *pl. 17*. 1811.

14. HOLOMITRIUM CALYCINUM (Sw.) Mitt. Jour. Linn. Soc. 12: 60. 1869

Bryum calcycinum Sw. Prod. 139. 1788.
Weisia calycina Hedw. Sp. Musc. 70. 1801.
Cecalyphum? calicinum Beauv. Prod. Aetheog. 50. 1805.
Dicranum calycinum Sw. Fl. Ind. Occ. 3: 1768. 1806.

HABITAT AND TYPE LOCALITY: "On roots of trees in high mountains. Jamaica."

DISTRIBUTION: Known only from Jamaica.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 14. f. 1–5*.

15. FISSIDENS PALMATUS (Sw.) Hedw. Descr. 3: 69. 1792

Hypnum palmatum Sw. Prod. 140. 1788.
Dicranum palmatum Sw. Fl. Ind. Occ. 3: 1774. 1806.
Skitophyllum palmatum De la Pyl. Jour. de Bot. II. 4: 146. 1814.

HABITAT AND TYPE LOCALITY: "In shady clayey places at roots of palms. Jamaica. Collected also on high trunk of *Areca oleracea*, in a cavity filled with rotten leaves."

DISTRIBUTION: Jamaica, Cuba, and St. Thomas.

ILLUSTRATIONS: Hedw. Descr. *pl. 30A*. 1792 (from Swartz' type); De la Pyl. Jour. de Bot. *pl. 35. f. 6*. 1814.

EXSICCATAE: Sull. Musci Cub. Wright. *11*.

16. FISSIDENS POLYPODIOIDES (Sw.) Hedw. Descr. 3: 63. 1792

Hypnum polypodioides Sw. Prod. 140. 1788.
Dicranum polypodioides Sw. Fl. Ind. Occ. 3: 1772. 1806.
Skitophyllum polypodioides De la Pyl. Jour. de Bot. II. 3: 153. 1814.

HABITAT AND TYPE LOCALITY: "On the ground in shady mossy slopes in high mountains, Jamaica."

DISTRIBUTION: Georgia, Alabama, Florida, and Louisiana; Jamaica, Cuba, Haiti, Porto Rico; Dominica, Guadeloupe, and Martinique, to South America; also, Mexico, Guatemala, and Panama.

ILLUSTRATIONS: Sull. Icon. Musc. *pl. 27;* De la Pyl. l. c. *pl. 38. f. 10.*

EXSICCATAE: Drummond, Musci Am. ed. 2. *38;* Sull. & Lesq. Musci Bor. Am. ed. 2. *87*: Sull. Musci Cub. Wright. *10;* Small, Mosses So. U. S. *9;* Husnot, Pl. Ant. Fr. *133*.

17. FISSIDENS ASPLENIOIDES (Sw.) Hedw. Descr. **3**: 65. 1792

Hypnum asplenioides Sw. Prod. 140. 1788.
Dicranum asplenioides Sw. Fl. Ind. Occ. **3**: 1770. 1806.
Skitophyllum asplenioides De la Pyl. Jour. de Bot. II. **4**: 156. 1814.
Fissidens Barbae-montis C. Müll.; Ren. & Card. Bull. Soc. Roy. Bot. Belg. **31**[1]: 152. 1892.
Fissidens costaricensis Besch. Bull. Herb. Boiss. **2**: 390. 1894.

HABITAT AND TYPE LOCALITY: "On mossy rocks in high mountains of Jamaica."

DISTRIBUTION: Jamaica and St. Kitts; also Mexico and Costa Rica.

ILLUSTRATIONS: Hedw. Descr. *pl. 28* (from type); De la Pyl. Jour. de Bot. II. **4**: *pl. 38. f. 8, 9.*

EXSICCATAE: Pringle, Musci Mex. *10,503*.

18. PHYLLOGONIUM FULGENS (Sw.) Brid. Bryol. Univ. **2**: 671. 1827

Hypnum fulgens Sw. Prod. 140. 1788.
Pterigynandrum fulgens Hedw. Descr. **4**: 101. 1797.
Pterogonium fulgens Sw. Fl. Ind. Occ. **3**: 1776. 1806.
? *Phyllogonium viride* Brid. Bryol. Univ. **2**: 673. 1827.
Phyllogonium aureum Mitt. Journ. Linn. Soc. **12**: 424. 1869.
Phyllogonium globitheca C. Müll. Bull. Herb. Boiss. **5**: 563. 1897.

HABITAT AND TYPE LOCALITY: "Dependent from branches of trees in high mountains of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Porto Rico, St. Kitts, Antigua, Montserrat, Guadeloupe, Martinique, St. Vincent, and Grenada to Trinidad. Also in South America.

ILLUSTRATION: Hedw. Descr. *pl. 39* (from type).

EXSICCATAE: Sull. Musci Cub. Wright. *131;* Husnot, Pl. Ant. Fr. *154.*

There is some doubt as to what the type specimen of *Phyllogonium viride* of Bridel is. The type locality is Brazil and it is just possible that the name may antedate either *P. immersum* Mitt. or *P. Serra* C. Müll. Both these species were distributed by E. Ule in his Bryotheca Brasiliensis no. 81 from Serra Geral, Province of Santa Catharina, Brazil. All the West Indian specimens, so-called, are referable to *P. fulgens.*

19. LEPIDOPILUM DIAPHANUM (Sw.) Mitt. Jour. Linn. Soc. 12: 382. 1869

Hypnum diaphanum Sw. Prod. 140. 1788.
Hypnum diaphanum Hedw. Sp. Musc. 243. 1801.
Hypnum? diaphanum Sw. Fl. Ind. Occ. 3: 1828. 1806.
Pterygophyllum diaphanum Brid. Bryol. Univ. 2: 345. 1827.
Hookeria diaphana W.-Arn. Disp. Musc. 56. 1825.

HABITAT AND TYPE LOCALITY: "In depressions, mountains of Jamaica. Mixed with *Marchantia* and *Jungermannia.*"

DISTRIBUTION: Jamaica, Martinique.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 61. f. 1–6* (from type).

20. CYCLODICTYON ALBICANS (Sw.) Broth. in E. & P. Pfl. 1^3: 935. 1907

Hypnum albicans Sw. Prod. 140. 1788.
Hypnum albens Gmel. Syst. Nat. 2: 1343. 1791.
Leskea albicans Hedw. Sp. Musc. 218. 1801.
Leskea albicans Sw. Fl. Ind. Occ. 3: 1811. 1806.
Hypnum pallidum Brid. Musc. Rec. 2^2: 127. 1806.
Pterygophyllum albicans Brid. Bryol. Univ. 2: 349. 1827.

HABITAT AND TYPE LOCALITY: "On old and rotten trunks of trees, temperate regions of Jamaica."

DISTRIBUTION: Jamaica, Guadeloupe, St. Vincent, and Mexico.

ILLUSTRATIONS: Hedw. Sp. Musc. 218. *pl. 54. f. 13–16* (from type).

EXSICCATAE: Pringle, Musci Mex. *10,664.*

21. HOMALIA GLABELLA (Sw.) Mitt. Jour. Linn. Soc. 12: 458. 1869

Hypnum glabellum Sw. Prod. 140. 1788.
Leskea glabella Hedw. Sp. Musc. 235. 1801.
Neckera glabella Sw. Fl. Ind. Occ. 3: 1782. 1806.

HABITAT AND TYPE LOCALITY: "On trunks of trees in mountains of Jamaica."

DISTRIBUTION: Jamaica, Porto Rico, Guadeloupe, Mexico, Costa Rica, to Venezuela.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 59* (from type specimens).

22. METEORIOPSIS PATULA (Sw.) Broth. in E. & P. Pfl. 1^3: 825. 1906

Hypnum patulum Sw. Prod. 140. 1788.
Hypnum patulum Hedw. Sp. Musc. 279. 1801.
Hypnum? patulum Sw. Fl. Ind. Occ. 3: 1832. 1806.
Leskea remotifolia C. Müll. Linnaea 19: 216. 1847.
Meteorium stellatum Lorentz, Moosst. 165. 1864.
Meteorium flaccidum Mitt. Jour. Linn. Soc. 12: 443. 1869.
Meteorium tenue Sch. Besch. Mém. Soc. Sc. Nat. Cherbourg 16: 227. 1872.
Meteorium diversifolium Besch. l. c.
Meteorium torticuspis C. Müll. Bull. Herb. Boiss. 5: 204. 1897.

HABITAT AND TYPE LOCALITY: "On roots and branches of trees near the summits, mountains of Jamaica."

DISTRIBUTION: Florida, in hammocks near Cutler, *J. K. Small;* Jamaica, Haiti, Porto Rico, Guadeloupe, Martinique, Dominica, Montserrat, St. Vincent, Grenada, and Trinidad to South America; also Mexico, Guatemala, Honduras, Costa Rica, and Panama.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 73*.

EXSICCATAE: Sull. Musci Cub. Wright. *80;* Husnot, Pl. Ant. Fr. *168;* Pringle, Musci Mex. *15,136*.

This is a common and variable species in the tropics and accordingly has received a variety of names. There seems to be no reason for maintaining two sections and such a host of names in this genus, for according to Mitten and R. S. Williams the following also are synonyms of this species: *M. aureo-nitens* Hampe (not Hook.), *M. barbipendulum* C. Müll.; *M. cirrifolium* Schw.,

M. chiriquense Ltz., *M. Eurhynchium* C. Müll., *M. Filicis* C. Müll., and *M. subambiguum* (Hampe) Paris.

23. MITTENOTHAMNIUM REPTANS (Sw.) Card. Rev. Bryol. **40**: 21. 1913

Hypnum reptans Sw. Prod. 140. 1788.
Hypnum reptans Hedw. Sp. Musc. 265. 1801.
Hypnum reptans Sw. Fl. Ind. Occ. 3: 1819. 1806.
Microthamnium reptans Mitt. Jour. Linn. Soc. **12**: 506. 1869.
Hypnum pseudo-reptans C. Müll. Bot. Zeit. **14**: 439. 1856.
Microthamnium Turckheimii C. Müll. Bull. Herb. Boiss. **5**: 215. 1897.
Microthamnium minusculum C. Müll. Bull. Herb. Boiss. **5**: 565. 1897.
Stereohypnum reptans Fleisch. Hedwigia **47**: 275. 1908.

HABITAT AND TYPE LOCALITY: "On earth and trunks of trees, interior of Jamaica."

DISTRIBUTION: Cuba, Jamaica, Guadeloupe, Martinique, Mexico, Guatemala, Nicaragua, Costa Rica, Panama, and South America.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 68.*

24. POROTRICHUM FASCICULATUM (Sw.) Mitt. Jour. Linn. Soc. **12**: 468. 1869

Hypnum fasciculatum Sw. Prod. 140. 1788.
Hypnum fasciculatum Hedw. Sp. Musc. 245. 1801.
Hypnum? fasciculatum Sw. Fl. Ind. Occ. 3: 1827. 1806.
Thamnium fasciculatum C. Müll. Hedwigia **37**: 260. 1898.

HABITAT AND TYPE LOCALITY: "On roots of trees; high mountains of Jamaica."

DISTRIBUTION: Jamaica, Porto Rico, and Trinidad to South America.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 62. f. 8–10* (from Swartz' specimens).

25. HYPOPTERYGIUM TAMARISCI (Sw.) Brid. Bryol. Univ. **2**: 715. 1827

Hypnum Tamarisci Sw. Prod. 141. 1788.
Leskea Tamariscina Hedw. Sp. Musc. 212. 1801.

Hypnum Tamarisci Sw. Fl. Ind. Occ. 3: 1825. 1806.
Hypopterygium brasiliense Sull. U. S. Expl. Exp. 26. 1859.
?*Hypopterygium pseudo-tamarisci* C. Müll. Linnaea 38: 645. 1874.

HABITAT AND TYPE LOCALITY: "On trunks of trees, creeping among mosses in the cold regions of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, and Porto Rico; also in Mexico, Guatemala, Costa Rica, and South America.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 62. f. 8–10;* Sull. U. S. Expl. Exped. *pl. 26.*

EXSICCATAE: Sull. Musci Cub. Wright. *130;* Pringle, Musci Mex. *10,497.*

26. PILOTRICHELLA FLEXILIS (Sw.) Jaeg. Adumb. 2: 162. 1875–76

Hypnum flexile Sw. Prod. 141. 1788.
Leskea flexilis Hedw. Sp. Musc. 234. 1801.
Hypnum? flexile Sw. Fl. Ind. Occ. 3: 1830. 1806.
Meteorium flexile Mitt. Jour. Linn. Soc. 12: 438. 1869.
Neckera cochlearifolia C. Müll. Syn. 2: 130. 1851.
Neckera turgescens C. Müll. Syn. 2: 131. 1851.
Pilotrichella eroso-mucronata C. Müll. Bull. Herb. Boiss. 5: 563. 1897.
Pilotrichella recurvo-mucronata C. Müll. Bull. Herb. Boiss. 5: 563. 1897.

HABITAT AND TYPE LOCALITY: "Summits of mountains in Southern Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Porto Rico, Guadeloupe; Mexico, Guatemala, Nicaragua, Costa Rica, Panama; Colombia, Ecuador, Bolivia, and Brazil.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 58.*

EXSICCATAE: Pringle, Musci Mex. *10,420, 10,468,* Grout, N. A. Musci Pleur. *389.*

27. PAPILLARIA NIGRESCENS (Sw.) Jaeg. Adumb. 1: 169. 1875–76

Hypnum nigrescens Sw. Prod. 141. 1788.
Hypnum nigrescens Hedw. Sp. Musc. 250. 1801.
Pterogonium nigrescens Sw. Fl. Ind. Occ. 3: 1778. 1806.
Neckera nigrescens Schwaegr. Suppl. 3^2. 1828.

Meteorium nigrescens Mitt. Jour. Linn. Soc. 12: 441. 1869.
Papillaria nigrescens Donnellii Aust. Musci App. Suppl. 14. 1898.

HABITAT AND TYPE LOCALITY: "On branches of trees, high mountains of Jamaica. Collected on *Anacardium occidentale*."

DISTRIBUTION: Louisiana, Florida, and the Bahamas; Jamaica, Cuba, Haiti, Porto Rico, Barbados, and Trinidad to South America; also in Lower California, Mexico, Guatemala, Costa Rica, and Panama. Also in South America.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 65*. 1801; Schwaegr. Suppl. *pl. 244*. 1828; Bryologist 7: 14. 1904.

EXSICCATAE: Austin, Musci App. Suppl. *533*, Sull. Musci Cub. Wright. *83*.

The var. *Donnellii* is simply a xerophytic condition in which the leaves fall off and the terminal branches become brittle, thus propagating the species; in fact, the fruit is seldom found. Austin and J. D. Smith collected it at Caloosa, Florida, in 1876–78 and Mr. Severin Rapp has reported it from Sanford. In all our Jamaica collections I have found it but once, on a calabash tree.

28. PRIONODON DENSUS (Sw.) C. Müll. Bot. Zeit. 2: 130. 1844

Hypnum densum Sw. Prod. 141. 1788.
Hypnum densum Hedw. Sp. Musc. 282. 1801.
Hypnum? densum Sw. Fl. Ind. Occ. 3: 1829. 1806.
Neckera crassa Hornsch. Fl. Brasil. 1: 56. 1840.
Pilotrichum densum C. Müll. Syn. 2: 160. 1850.

HABITAT AND TYPE LOCALITY: "In Blue Mountains, southern Jamaica, on roots of trees."

DISTRIBUTION: Jamaica, Cuba, Haiti, Mexico, Costa Rica, and Panama, 1,500–2,000 ft.; also in South America.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 74* (from Swartz' type): Bot. Zeit. 2: *pl. 1*.

EXSICCATAE: Pringle, Musci Mex. *10.483*.

29. PILOTRICHUM COMPOSITUM (Sw.) P. Beauv. Prod. 82. 1805

Hypnum compositum Sw. Prod. 141. 1788.
Neckera composita Hedw. Sp. Musc. 203. 1801.
Neckera composita Sw. Fl. Ind. Occ. 3: 1792. 1806.

HABITAT AND TYPE LOCALITY: "On trunks of trees in woods, interior of Jamaica."

DISTRIBUTION: Jamaica and Grenada ("Costa Rica"?).

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 16. f. 8–13* (from Swartz' type).

30. LEPIDOPILUM POLYTRICHOIDES (Sw.) Brid. Bryol. Univ. **2**; 269. 1827

Hypnum polytrichoides Sw. Prod. 141. 1788.
Hypnum polytrichoides Hedw. Sp. Musc. 244. 1801.
Orthotrichum polytrichoides Brid. Musc. Recent. 2^2: 31. 1801.
Neckera polytrichoides Sw. Fl. Ind. Occ. **3**: 1794. 1806.
Lepidopilum polytrichoides var. *costaricense* Ren. & Card. Bull. Soc. Roy. Bot. Belg. 32^1: 192. 1893.
Hookeria Carionis C. Müll. Bull. Herb. Boiss. **5**: 205. 1897.

HABITAT AND TYPE LOCALITY: "On branches of trees and shrubs, also on rocks, mountains of Jamaica and Hispaniola."

DISTRIBUTION: Jamaica, Cuba, Haiti, Porto Rico, Guadeloupe, Martinique, Montserrat, and St. Vincent to South America: also, Mexico, Guatemala, Costa Rica, and Panama.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 61* (from Swartz' type); Schwaegr. Suppl. **3**: *pl. 231*.

EXSICCATAE: Husnot, Pl. Ant. Fr. *156*.

31. HELICODONTIUM CAPILLARE (Sw.) Jaeg. Adumb. **2**: 225. 1876–77

Hypnum capillare Sw. Prod. 141. 1788.
Leskea capillaris Hedw. Descr. **4**: 25. 1793.
Leskea capillaris Sw. Fl. Ind. Occ. **3**: 1813. 1806.

HABITAT AND TYPE LOCALITY: "On trunks of trees, interior of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Porto Rico; also in Mexico and South America.

ILLUSTRATION: Hedw. Descr. **4**: *pl. 10*.

EXSICCATAE: Sull. Musci Cub. Wright. *70;* Pringle, Musci Mex. *759*.

32. RHACOPILUM TOMENTOSUM (Sw.) Brid. Bryol. Univ. 2: 719. 1827

Hypnum tomentosum Sw. Prod. 141. 1788.
Hypnum tomentosum Hedw. Descr. 4: 48. 1793.
Hypnum tomentosum Sw. Fl. Ind. Occ. 3: 1823. 1806.
Rhacopilum tomentosum var. *gracile* Besch. Mém. Soc. Sci. Nat. Cherbourg. 16: 257. 1872.

HABITAT AND TYPE LOCALITY: "On roots of trees near rivers, temperate regions of Hispaniola."

DISTRIBUTION: Louisiana, Bermuda, Cuba, Jamaica, Haiti, Santo Domingo, Guadeloupe, to Trinidad and South America; Mexico, Costa Rica, Guatemala, Nicaragua, and Panama; also in Asia and Africa.

ILLUSTRATIONS: Hedw. Descr. *pl. 19;* Bryologist 10: *pl. 5*.

EXSICCATAE: Sull. Musci Cub. Wright. *74;* Pringle, Musci Mex. *10,501*.

33. CALLICOSTELLA DEPRESSA (Sw.) Jaeg. Adumb. 2: 352. 1875–76

Hypnum depressum Sw. Prod. 141. 1788.
Leskea depressa Hedw. Sp. Musc. 215. 1801.
Leskea depressa Sw. Fl. Ind. Occ. 3: 1804. 1806.

HABITAT AND TYPE LOCALITY: "On bark of trees, mountains of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Porto Rico, Haiti, and Guadeloupe.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 53. f. 1–7* (from Swartz' type).

34. **Clastobryum trichophyllum** (Sw.) E. G. Britton, comb. nov.

PLATE 25

Hypnum trichophyllum Sw. Prod. 141. 1788.
Hypnum trichophyllum Hedw. Sp. Musc. 274. 1801.
Neckera trichophylla Sw. Fl. Ind. Occ. 3: 1798. 1806.
Lepyrodon trichophyllus Mitt. Jour. Linn. Soc. 12: 422. 1869.
Leucodon trichophyllus Jaeg. Adumb. 2: 122. 1877.
Lepyrodon trichophyllus robustior Besch. Ann. Sci. Nat. VI. 3: 224. 1876.

Palamocladium trichophyllum C. Müll. Flora **82**: 465. 1896.
Palamocladium trichophyllum subtile C. Müll. Hedwigia **37**: 240. 1898.
Orthothecium trichophyllum Fleisch. Fl. Buit. **3**: 667. 1906.

Plants light yellowish green, glossy; stems rooting and creeping, with simple erect branches, often 2 cm. high and prolonged into slender flagellate branchlets bearing brown septate gemmae in clusters in the axils of the upper leaves; branch-leaves crowded, spreading, glossy, strongly plicate when dry, lanceolate-acuminate, 3–5 mm. long, ecostate, margins plane, serrate; cells linear, walls porose, slightly thickened, alar cells shorter and broader, curved, forming a small, serrate auricle. Autoicous, perichaetial leaves shorter, paler, more suddenly subulate, more sharply serrate. Seta erect, straight or flexuose, red, 15–25 mm. long; calyptra cucullate; capsule erect, ovoid-cylindric, sometimes contracted below the mouth when dry, 2–3 mm. long, lid rostrate; annulus none; walls with irregular square or hexagonal cells 27–54 μ long $\times$ 27μ wide; neck short, stomatose; peristome double; teeth incurved, brown, narrow, not perforate, papillose, with slightly trabeculate lamellae; endostome paler, also papillose with a short basal membrane and rudimentary or imperfect cilia, segments shorter than the teeth, not split along the keel; spores green, minutely papillose, unequal in size, 5μ–16μ, maturing in winter.

Forming bright glossy mats in shade on trunks and roots of tree-ferns and palms on high mountains, rarely on rocks. Fruit rare!

HABITAT AND TYPE LOCALITY: "On bark and trunks of old trees, Jamaica."

DISTRIBUTION: Jamaica, Cuba, Porto Rico, Haiti, Santo Domingo, St. Kitts, Dominica, Martinique. Guadeloupe, St. Vincent, Montserrat, and Trinidad to Venezuela.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 71;* E. & P. Nat. Pfl. 1^3: *773. f. 580 J–L.*

EXSICCATAE: Husnot, Pl. Ant. Fr. *183*, as *Meteorium sericeum* Sch.

On account of the rarity of its fruit this species has been placed in a variety of genera none of which seem to me to be correct. Its double peristome and different habit remove it from *Lepyrodon* and its tropical distribution from *Orthothecium*, the species of which are alpine or arctic and subarctic. Its relationship however seems to me to be more with the *Entodontaceae*, where Fleischer

has placed it; the presence of septate gemmae, and the ecostate leaves and more or less imperfect endostome, show its relationship to *Clastobryum indicum* Dozy & Molk. as figured by Brotherus (E. & P. Nat. Pfl. 1^3: 874. *f. 640*. 1907) but the leaf cells are porose and the walls are thickened as shown on the same page in *f. 639* of *C. planulum* Mitt.

Clastobryum americanum Cardot, originally described from Mexico, also occurs on the slopes and summit of Sir John Peak above Cinchona, in the Blue Mountains of Jamaica, and Mr. R. S. Williams has collected it in Bolivia at 8,000 ft. near Cargadera in 1902.

35. THUIDIUM MICROPHYLLUM (Sw.) Jaeg. Adumb. 2: 251. 1876–77

Hypnum microphyllum Sw. Prod. 142. 1788.
Hypnum microphyllum Hedw. Sp. Musc. 269. 1801.
Hypnum microphyllum Sw. Fl. Ind. Occ. 3: 1821. 1806.
Hypnum calyptratum Sull. Pac. R. R. Rep. 4: 190. 1856.

HABITAT AND TYPE LOCALITY: "On roots of trees, Jamaica."

DISTRIBUTION: Canada to Florida and the Bahamas, Jamaica, Cuba, and Mexico.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 69* (from Swartz' type); Sull. l. c. *pl. 100*.

EXSICCATAE: Sull. Musci Cub. Wright. *99*.

36. SEMATOPHYLLUM CAESPITOSUM (Sw.) Mitt. Jour. Linn. Soc. 12: 479. 1869

Hypnum caespitosum Sw. Prod. 142. 1788.
Leskea caespitosa Hedw. Sp. Musc. 233. 1801.
Leskea caespitosa Sw. Fl. Ind. Occ. 3: 1807. 1806.
Rhaphidostegium caespitosum Jaeg. Adumb. 2: 454. 1875–76.
*Hypnum loxense** Sull. Proc. Am. Acad. Arts & Sci. 5: 287. 1861.
Not Hooker, 1822.

HABITAT AND TYPE LOCALITY: "On roots of trees, mountains of Hispaniola."

DISTRIBUTION: Cuba, Jamaica, Haiti, Porto Rico, Guadeloupe,

* The real *Sematophyllum loxense* (Hook.) Jaeg. has been found in Cuba.

and Martinique, to Trinidad and South America; also Mexico and Costa Rica.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 49.*

37. SEMATOPHYLLUM PUNGENS (Sw.) Mitt. Jour. Linn. Soc. 12: 477. 1869

Hypnum pungens Sw. Prod. 142. 1788.
Hypnum pungens Hedw. Sp. Musc. 237. 1801.
Leskea pungens Sw. Fl. Ind. Occ. 3: 1806. 1806.
Pungentella pungens C. Müll. Hedwigia 37: 260. 1898.

HABITAT AND TYPE LOCALITY: "Roots of trees in moist woods, mountains of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Porto Rico, Virgin Islands, Guadeloupe, Martinique, and Dominica to South America; also Mexico and Guatemala to Panama.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 60* (from Swartz' type).

EXSICCATAE: Sull. Musci Cub. Wright. *104;* Husnot, Pl. Ant. Fr. *186.*

38. PLEUROPUS CONGESTUS (Sw.) Broth. E. & P. Nat. Pfl. 1^3: 1138. 1908

Hypnum congestum Sw. Prod. 142. 1788.
Hypnum congestum Hedw. Sp. Musc. 283. 1801.
Leskea congesta Sw. Fl. Ind. Occ. 3: 1809. 1806.
Homalothecium congestum Jaeg. Adumb. 2: 311. 1877–78.

HABITAT AND TYPE LOCALITY: "On old trunks of trees, interior of Jamaica."

DISTRIBUTION: Jamaica, Haiti, Montserrat, and Dutch Guiana.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 74. f. 4–7.* 1801.

Excepting for the illustration given by Hedwig, little is known of this species in modern times. Mitten and Brotherus had not seen specimens. At the British Museum there is a specimen labelled "*Leskea congesta* Sw. Ind. Occ. ex *Cl. Swartzio.* J. Vahl," which is evidently a mixture of *Palamocladium leskeoides* and *Clastobryum trichophyllum.* Hedwig's description calls for a plant with entire somewhat secund, falcate leaves and a horizontal capsule, characters which do not agree with either of the species named above.

The synonymy of *Palamocladium* is as follows:

Palamocladium leskeoides (Hook.) E. G. Britton, comb. nov.
Hookeria leskeoides Hook. Musc. Exot. *pl. 55*. 1818.
Leskea Bonplandi Hook.; Kunth. Syn. Pl. Aeq. 1: 61. 1822.
Hypnum Bonplandi C. M. Syn. 2: 463. 1851.
Homalothecium Bonplandi Jaeg. Adumb. 2: 379. 1875–76.
Palamocladium Bonplandi Broth. Bot. Jahrb. 24: 281. 1897.
Isothecium Bonplandi haitense Ren. & Card. MS. in herb.
Pleuropus leskeoides Hook. MS. in Herb.

39. ORTHOSTICHOPSIS TETRAGONA (Sw.) Broth. E. & P. Nat. Pfl. 1[3]: 805. 1906

Hypnum tetragonum Sw. Prod. 142. 1788.
Hypnum? tetragonum Hedw. Sp. Musc. 246. 1801.
Hypnum? tetragonum Sw. Fl. Ind. Occ. 3: 1833. 1806.
Pterigynandrum aureum Brid. Mant. 101. 1819.
Pterigynandrum quadrifarium Brid. Bryol. Univ. 2: 194. 1827.
Isothecium tetragonum Brid. Bryol. Univ. 2: 377. 1827.
Neckera quinquefaria C. Müll. Syn. 2: 124. 1850.
Neckera tetragona C. Müll. Syn. 2: 125. 1850.
Meteorium tetragonum Mitt. Jour. Linn. Soc. 12: 431. 1869.
Pilotrichella tetragona Besch. Mém. Soc. Sci. Nat. Cherbourg 16: 223. 1872.

HABITAT AND TYPE LOCALITY: "On trunks of trees, near summits of mountains in Jamaica."

DISTRIBUTION: Jamaica, Cuba, Santo Domingo, to Trinidad and Guiana; also in Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama.

ILLUSTRATION: Hedw. Sp. Musc. *pl. 63*. 1801 (from Swartz' type).

This moss is not uncommon in Jamaica and was known to Hans Sloane* and Dillenius,† who called it "the square-branched *Hypnum* from Jamaica." Both of these authors figured it rather poorly.

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* Hist. Jam. 1: 68. *pl. 25. f. 3.* 1707.
† Hist. Musc. 335. *pl. 43. f. 73.* 1741.

40. SCHLOTHEIMIA TORQUATA (Sw.) Brid. Bryol. Univ. 1: 323. 1826

Hypnum torquatum Sw. Prod. 142. 1788.
Hypnum torquatum Hedw. Sp. Musc. 246. 1801.
Neckera torta Sw. Fl. Ind. Occ. 3: 1800. 1806.
Schlotheimia torta Schwaegr. Suppl. 1²: 39. 1816.
Schlotheimia pellucida C. Müll. Bull. Herb. Boiss. 5: 561. 1897.
Schlotheimia undato-rugosa C. Müll. Hedwigia 37: 238. 1898.

HABITAT AND TYPE LOCALITY: "On old mossy trunks of trees in woods, mountains of Jamaica."

DISTRIBUTION: Jamaica and Cuba, 5,000–6,000 ft. alt.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 63. f. 4-7* (from Swartz' type).

EXSICCATAE: Sull. Musci Cub. Wright. *52*.

41. MACROMITRIUM CIRRHOSUM (Sw.) Brid. Bryol. Univ. 1: 316. 1826

Hypnum cirrhosum Sw. Prod. 142. 1788.
Anoectangium cirrhosum Hedw. Sp. Musc. 42. 1801.
Neckera cirrhosa Sw. Fl. Ind. Occ. 3: 1802. 1806.
Schlotheimia cirrosa Schwaegr. Suppl. 3¹. 1827.

HABITAT AND TYPE LOCALITY: "On trunks of trees, temperate parts of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Santo Domingo, Porto Rico, St. Kitts, Guadeloupe, Martinique, Montserrat, and Trinidad to South America; also, Guatemala and Panama.

ILLUSTRATIONS: Hedw. Sp. Musc. *pl. 5;* Schwaegr. Suppl. *pl. 201A*.

EXSICCATAE: Sull. Musci Cub. Wright. *51;* Husnot, Pl. Ant. Fr. *144*.

42. THUIDIUM INVOLVENS (Hedw.) Mitt. Jour. Linn. Soc. 12: 575. 1869

Leskea involvens Hedw. Descr. 4: 27. 1794.
Leskea involvens Swartz, Fl. Ind. Occ. 3: 1815. 1806.

HABITAT AND TYPE LOCALITY: "With *Helicodontium capillare* on trunks of trees, interior of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Porto Rico, Guadeloupe, and Barbados to South America; also Mexico (Yucatan).

ILLUSTRATION: Hedw. Descr. *pl. 11* (from Swartz' type).

EXSICCATAE: Sull. Musci Cub. Wright. *98*.

43. **Turckheimia linearis** (Sw.) E. G. Britton, comb. nov.

Tortula linearis Sw. Fl. Ind. Occ. 3: 1765. 1806.
Barbula linearis Brid. Mant. Musc. 88. 1819.
Trichostomum lineare Broth. E. & P. Nat. Pfl. 1³: 394. 1902.

HABITAT AND TYPE LOCALITY: "On dry calcareous rocks, Hispaniola."

DISTRIBUTION: Jamaica, Cuba, and Haiti.

Our specimens from Jamaica and Cuba have a well-developed, slender peristome, which disappears from the old capsules. I believe this species to be congeneric with *Turckheimia guatemalensis* Broth., which also shows traces of a peristome though the capsules are all old. The section of the leaf in *T. linearis* is remarkable for having two rows of guide-cells of about 10 cells each in the costa, with a stereid band both above and below. The costa is rather broader than in *T. guatemalensis* and smooth on the dorsal side, showing as a prominent white rib to the leaf. It is papillose on the upper surface and the cells of the blade bear several minute papillae on both surfaces. This peculiarity of the costa removes *Turckheimia linearis* from *Trichostomum;* and although there is but a single row of guide-cells in *T. guatemalensis*, their macroscopic resemblance is so close that they appear to be congeneric.

44. ISOPTERYGIUM TENERUM (Sw.) Mitt. Jour. Linn. Soc. 12: 499. 1869

Hypnum tenerum Sw. Fl. Ind. Occ. 3: 1817. 1806.

HABITAT AND TYPE LOCALITY: "On trunks of trees, mountains of Jamaica."

DISTRIBUTION: Jamaica, Cuba, Haiti, Guadeloupe, Martinique, St. Lucia, to Trinidad and South America; also Bermuda, and Louisiana to Florida.

EXSICCATAE: Sull. Musci Cub. Wright. *107*.

According to Dr. Andrews' notes "the Swartz specimens, which are deposited in the collections of the Naturhistoriska Riksmuseum at Stockholm, are distributed through the herbarium of non-Scandinavian mosses, which are, in general, arranged after Paris's Index. Packets are generally uniform, one to many on the herbarium sheet. Swartz' specimens are recognizable by labels in his handwriting included in the packet, by the kind of paper with water-mark to which he pasted them and references of others to the origin of specimens."

We have seen specimens of all but two of these species, and have duplicates of many of them; it is therefore our intention to distribute sets of these and other West Indian mosses, in exchange for other exsiccatae and duplicates from the West Indies, Central America, and South America.

NEW YORK BOTANICAL GARDEN

Explanation of plate 25

Clastobryum trichophyllum (Sw.) E. G. Britton

The figures were drawn from magnifications three times as great as expressed in the numbers, which represent the magnifications of the figures as they stand in the reproduction.

1. Plant, natural size.
2. Portion of branch showing the flagellate branches and gemmae, × 2⅔.
3. Outline of stem leaf, × 16⅔.
4, 5. Outlines of branch leaves, × 16⅔.
6. Apex of leaf, × 108.
7. Basal portion of leaf, showing the auricle, × 108.
8. Median cells, × 263.
9. Apex of leaf showing the pores in the walls of the apical cells, × 263.
10. Cross section of leaf, × 140.
11. Branch with gemmae, × 85.
12. Gemma, × 138.
13. Cross section of stem, × 140.
14. Perichaetial bud, leaves of one side removed to show the paraphyses and archegonia, × 12.
15. Capsule, × 10.
16. Calyptra, × 10.
17. Stoma from base of capsule, × 195.
18. Portion of peristome and upper part of capsule, × 195.
19. Spores, × 195.

Phytogeographical notes on the Rocky Mountain region
I. Alpine region

P. A. Rydberg

The alpine region, roughly speaking, is the region between the perpetual snow and the timber line.

The upper limit, the perpetual snow line

A perpetual snow line cannot be spoken of in the southern Rockies. Even the highest peaks do not have a perpetual snow cap like Mt. Shasta or Mt. Hood. This is probably due to the less amount of moisture and precipitation. It is true that many of the peaks have perpetual snow on them, but this snow is mostly in the form of snow-drifts and small glaciers, especially on the northern or northeastern side. The amount of snow depends to a great extent on local conditions, as for instance on an exposure to the northwestern winds or partial protection from the direct action of the summer sun. The Snowy Range of Colorado has more snow than the much higher Gray's Peak, Sierra Blanca, or Mount Massive. In the Canadian Rockies and especially in the Selkirk Mountains the conditions are different and more like those of the European Alps. There the highest peaks have a perpetual snowcap and the glaciers extend far down in the valleys. In northern Montana, as for instance in the Sperry Glacier region, are found the only places in the United States where in the Rockies there are glaciers of any great extent, notwithstanding the fact that the Montana mountains are considerably lower than those of Colorado.

The lower limit, the timber line

The timber line is by no means a well-defined boundary line. It is in reality a broad zone in which the woody vegetation gradually thins out from the dense forest to the last krumholz. In nature there is not found any sharp line between two regions, but only a gradual transition zone between them.

Different authors have fixed the timber line differently, as for instance:

1. At the forest line; i. e., where the continuous forest stops.

2. At the grove line; i. e., where the trees cease to form communities of larger or smaller size.

3. At the tree line; i. e., where the arboreal species cease to form trees.

4. The absolute timber line; i. e., where these species disappear altogether, even as krumholz.

To me it seems superfluous to consider more than two of these "lines," viz. the "forest line" and the "absolute timber line," which may be called the Lower and the Upper Timber Lines. But to fix the limit between the alpine region and the subalpine region at either of the two would be erroneous in certain respects. The region between these two timber lines is a transition zone between the two, or it may be still better called a zone of strife. A continuous warfare goes on between the forest and the alpine grassland. A seed from the forest succeeds in germinating between the low alpine plants. A tree grows up. The alpine plants are smothered in the shade. More tree seeds have a chance to germinate and a grove is formed and the forest region is carried upwards.

On the other hand, snow and wind kill the trees on the edge of the forest or the grove, the shade is gone and the alpine plants soon take possession. But more on this subject below.

The width of this transition zone or zone of strife depends on many factors. In one place the forest meets a steep cliff and stops abruptly. In such places there is no transition zone. In other places the lower timber line has been pushed down by a ledge of snow thick enough to last the larger part of the summer and having the power of smothering the trees, but not the herbaceous alpine vegetation. Still above the lower timber line at these places, there might be found isolated trees or groves of trees a thousand feet higher up, especially on higher ground, where the snow has not been so deep. In other places the lower timber line might have been pushed down by wind, not so much by its mechanical force as by its desiccating effects.

In treating the alpine region, I would be inclined to place the boundary at the lower timber line, i. e., the forest line, so as to

include all open spaces of the transition zone as these have a flora alpine in character. In treating the subalpine region, however, I would place the boundary at the absolute timber line, so as to include the groves, isolated trees, and krumholz as well. The groves, if of any size, contain not only the trees themselves, but also wood plants and underbrush belonging to the subalpine region. They are either encroaching on the region above or are themselves remnants of a former forest. So are also the isolated trees and krumholz, although not associated with other plants of the forest.

In a mountain region extending through twenty degrees of latitude, from lat. 35° to lat. 55° (the Rockies north of 55° have not been considered in my work), the altitude of the timber line necessarily varies greatly. In Colorado the lower timber line is found at an altitude of between 3,200 and 3,400 m. and the upper at 3,400 to 3,500 or rarely 3,600 m. In Montana the lower one is at 2,200–2,500 m. and the upper 2,500–2,700 m. In the Canadian Rockies they are even lower.

FACTORS GOVERNING THE TIMBER LINE

The conditions that have been given as causing or modifying the timber line are:

1. A decreased temperature during the growing season.
2. Too short a growing season.
3. Late frost on account of lack of protection from snow.
4. Strong desiccating winds.
5. Deep snow.
6. Form of precipitation.
7. Large mountain masses.
8. Exposure to and protection from direct sunlight.
9. Physiographical barriers.
10. Ecological barriers.
11. Economic timber line.

LOW TEMPERATURE

It is natural that too low a temperature should be one of the important factors causing the disappearance of the forest. The temperature during the winter has, however, very little influence

upon the growing of trees. It is shown that the temperature in temperate regions in the winter often is much lower than in many places in the arctic. It is doubtful if the temperature in the alpine region of Colorado ever becomes as low as on the plains of Montana, where some years ago it was recorded as 65° F. below zero. The only place within the alpine region of the Rockies where a record has been kept during the winter is on the top of Pikes Peak, and here only for a few years. No such low temperature has been recorded there. It is during the growing season that a low temperature limit for forest growths can be spoken of, for during the winter, when the life functions of the plants lie dormant, a few degrees more or less makes in reality no difference. Köppen claims that no trees can grow at a place where the mean temperature during the warmest months of the year does not reach 10° C. Schroeter gives a table taken from the records of the meteorological central station at Zürich in which are given the mean temperatures in July at fifteen stations at the timber line in Switzerland. The mean temperature ranges from 7.75° C. at Zermatt to 15.4° at Monte Generoso. This shows that the timber line may reach a little higher than the isotherm 10° C. and in other cases not reach it. Schroeter is particular enough to mention that at Monte Generoso the low timber line is not an artificial one made by man. See below. The arctic timber line seems to be more coincident with the isotherm 10° C. for July than the timber line in the mountains.

SHORT GROWING SEASON

Another cause of the timber line is the shortness of the growing season. This, it may be, is just as important a factor as the preceding. When speaking of the arctic timber line, it is easy to see that this factor acts parallel to the preceding, for near the sea-level places of the same isotherm in the summer have about the same length of summer, but not so in the mountain regions. In the heads of valleys, where big snowdrifts are formed during the winter and melt late in the summer, and along glaciers and permanent snow the frost is kept longer in the ground and the growing season is naturally shortened. Therefore, in many places in the Rockies, the timber line is a thousand feet or more lower in the valley heads than on the slopes on the sides. The shortness of

the season may have also another effect on the timber line, i. e., the seeds would not have time to ripen. This may be of great importance in accounting for the arctic timber line, but it can have very little influence on the alpine timber line, for most of the conifers that reach the timber line have winged seeds, which are easily carried above the line of maturing seed and then can germinate there.

LATE FROST

Another factor which has been given as having effect on the timber line is late frost in the spring, killing the new sprouts. As the conifers, which are most affected, do not readily produce a second crop of shoots the same season, the forests after a few repeated frosts will soon be killed. In such a way large districts of pine forest were destroyed in Montana a few years ago.

STRONG DESICCATING WINDS

One of the most important factors is strong wind. This factor has been much underestimated in earlier times, but later writers on the phytogeography of the arctic regions have recognized it more and more. In my belief it is one of the most important factors in the Rockies. The trees at the timber line and especially those few isolated stragglers above the real forest line show marked effects from the wind. The trees are not only low, stunted, gnarled, ragged, with enormously elongated lower branches often spreading on the ground, but conspicuously one-sided, telling at the glance the direction of the prevailing winds. But the mechanical influence of the wind is not the most important, however. Of greatest importance are its desiccating effects, especially in the winter. This effect of the wind has been recognized even in arctic regions, but it must be taken into consideration still more in the mountains. The timber line is much lower on the north side of the Alps than on the south side. This is due not only to the difference in temperature (for the difference in altitude should not be so great), but still more to the desiccating northern winds. In some places in Montana these winds are northerly, but in southeastern Colorado and southern Utah they are from the southwest, and it is on this side of the mountains that the timber line is the lowest. In the Abajo Mountains of southeastern Utah, for

instance, there is no timber line at all on the southern and western sides, for no timber is growing between the semi-arid cedar-pinyon belt and the top of the mountains. The whole southern and western slopes of the mountains proper are covered by a semi-arid grass formation. The highest peaks (altitude about 11,000 feet) just reach the timber line on the eastern and northern sides, only one or two hundred feet belonging to the alpine region. The desiccating effects of the winds are increased by the thinness of the atmosphere.

DEEP SNOW

Deep snow is also a factor. As the desiccating wind lowers the altitude on the wind-swept ridges so does the snow in the heads of the valleys. I have already mentioned that the great snow-drifts or glaciers here shorten the growing season. But the snow-drifts have also a direct mechanical influence on the timber line in the way of smothering the tree vegetation. Herbs and low shrubs can withstand being covered by snow much better than a tree, for their growing season does not begin before the snow is practically off the ground, while the tops of the trees may be above the snow and exposed to the summer heat months before the snow cover of their roots and lower branches has melted. The lower portion of the tree is cut off from the air while the upper portion is already in vital activity. It is easy to distinguish trees stunted by the action of the wind from those stunted by the smothering snow. In the former the lower branches are enormously developed compared with the upper, and often creeping along the ground, while in the latter the lower branches are dead and covered by fungi or their mycelia.

The usual condition in the Rockies is, that wherever there is a large valley head, where the snow has a chance to lodge, this is always devoid of trees, except in places of higher ground, where the snow-drift has not been so deep and has had time to melt earlier in the summer. On such higher places there are often groves or isolated trees. The absence of trees in such a valley head is due less to the shortness of the season, produced by the snow, than to the smothering of the tree vegetation.

FORM OF PRECIPITATION

Another important factor influencing the timber line is the form of precipitation. In high altitudes the air is too rare to hold much moisture and the rain falls at the least lowering of the temperature. The rain falls therefore either in the form of mists or in light showers, which only wet the surface of the ground. It may be sufficient to keep alive the low rosettes or cushions of the alpine vegetation, but it is not sufficient for the deep-rooted trees. Furthermore, if a little heavier rain should come, the water would rush down the steep slopes of the mountains, not having time to sink down into the ground. The tops of the mountains are therefore arid, because the air is too rare to hold much moisture and quickly gives it up in light showers. Nowhere in the Rockies proper is the moisture very great. In the foot-hill regions and on the surrounding plains the temperature is too high in the summer to allow any precipitation. These zones are therefore also arid. It is at middle elevations that the precipitation is the greatest. The air here is dense enough to hold more moisture and the temperature low enough to allow precipitation. It is also at middle altitudes that we find the forest areas in the Rocky Mountain region.

LARGE MOUNTAIN MASSES

In the Swiss Alps, observations have been made that in regions of large mountain masses, as for instance in the Monte Rosa region and the Engadine and others, the timber line is higher than on isolated mountains. I have not seen any satisfactory explanation of this fact. It may be due partly to the fact that the central mountains of such massed groups are more or less protected from the desiccating winds. It may be due also to the circumstances that in the winter more snow lodges between the mountains, the melting of it is more retarded, and the water is more arrested in its downward course by the trees and their roots. The air in the summer time would be therefore, from the evaporation, more loaded with moisture, which would naturally also benefit the mountain tops. Whatever the real cause may be, it seems as if the observations made in Switzerland hold good in the Rockies. From my own experience, I know that the timber line in the isolated Belt Mountains and Crazy Mountains in Montana

is much lower than in the main Rockies, as for instance in the Yellowstone Park. The Belt Mountains would not be high enough to have a timber line if they were in the Rockies. So also in the Wahsatch and La Sal Mountains, the timber line is much lower than in the Rockies of Colorado. Even in the Colorado Rockies themselves, the timber line seems to be higher in places where the mountains are more massed. So for instance is it higher on Mount Massive and other mountains around Leadville than on the more isolated Pikes Peak, Sierra Blanca, or Longs Peak. I understand that on the isolated Mount Shasta, the timber line is much lower down than on the peaks of the Sierra Nevada, but here it may depend upon the proximity of the ocean, the greater moisture, and the consequently larger snowcap on Mount Shasta.

EXPOSURE TO SUNLIGHT

Exposure to the direct sunlight and protection from it evidently also have influence on the altitude of the timber line, though perhaps not so much as one might expect. The insolation on the mountain tops in direct sunlight is very great. Schroeter estimates that on the top of Mont Blanc it is 26 per cent stronger than in Paris. The Rockies of Colorado have about the same height as Mont Blanc and are situated from 5° to 8° farther south, and the insolation is fully as great. The amount of light and heat which can be absorbed by the plant is therefore much greater on the mountain tops than on the plains. The radiation is also very great in the higher altitudes so that the temperature in the shadow is much lower. According to Schroeter the timber line lies 100–200 meters higher on the southern side than on the northern, and DeCandolle claims that the limiting line of vegetation, of plants in general, is at an average of 200–300 meters higher on the equatorial side. These statements cannot be verified in the Rockies. The timber line in Colorado is, perhaps, higher on the northern side, but this is probably due to other conditions. The timber line trees of Colorado are mainly *Picea Engelmannii*, *Abies subalpina*, and *Pinus aristata*. The first two are trees that need a great deal of moisture, and their seedlings require shade. These two trees are therefore more confined to the more shady and wetter northern slopes, where they also

extend higher up. *Pinus aristata* is a tree that stands much more drought and is found more on the southern slopes, but it is a tree of little value as a forest tree, growing scatteringly only. To me it appears to be a species which has passed its best development and is in process of dying out.

PHYSIOGRAPHICAL BARRIERS

One of the conditions modifying the altitude of the timber line is to be found in physiographical barriers. Among these may be counted snowdrifts and glaciers, but these have been already mentioned. Besides these, the most important are precipitous cliffs and rock-slides. Very little needs to be said about these barriers. Neither gives the forest trees a chance to grow. Meeting one of these barriers, the timber may cease to grow thousands of feet below the physiological timber line. Wherever a steep cliff arrests the forest, many of the alpine plants will be found growing in the crevices, hundreds or even a thousand feet lower than usual, and there are a few plants characteristic of the rock-slides. These may be best included in the alpine vegetation.

ECOLOGICAL TIMBER LINE

Sometimes an ecological timber line is mentioned, i. e., where bacteria in the soil and other organisms necessary for the growth of trees cease to exist. Theoretically, I can easily see that such a timber line may exist, but practically I have no information that such a one is found in the Rocky Mountains, distinct from the merely physiological one. No investigation in this line has been made.

ECONOMIC TIMBER LINE

In Switzerland there exists also an economic timber line. The alpine meadows are there used as summer pastures for sheep and goats. These animals make depredations on the young trees and hinder the spreading of the forest, but in many places the subalpine forest is actually cut down by men to make room for more pastures. In either case the alpine conditions will be brought further down the mountains and the timber line lowered. Such an economic timber line cannot be said to exist in the Rockies.

ALPINE VEGETATION

After having discussed the causes of the timber line, it is easier to define what an alpine plant is. In short, it is a plant that can endure the climate of the mountains above the timber line. It is a plant that requires less heat during the growing season than the forest trees, or that can survive a shorter growing season, or is less affected by frost, and besides can better withstand desiccating winds, deep snow, reduced precipitation, etc., or a combination of such conditions. Some authors claim that alpine and arctic plants are xerophytes, but they are not necessarily so. While most of the plants of alpine and arctic regions can withstand a great deal of drought, in fact are xerophytic plants, it is not the case with all. Not a few of the arctic-alpine plants require a great deal of moisture, growing only below and around snowbanks, or in springy or boggy ground, as for instance several species of *Ranunculus*, *Saxifraga* (in extended sense), *Salix*, and many grasses and sedges. There are in the arctic-alpine regions even true aquatics, as for instance among the phanerogams, *Catabrosa aquatica*, *Phippsia algida*, *Sparganium minimum*, and *S. hyperboreum*, and a few species of *Potamogeton*.

NEW YORK BOTANICAL GARDEN

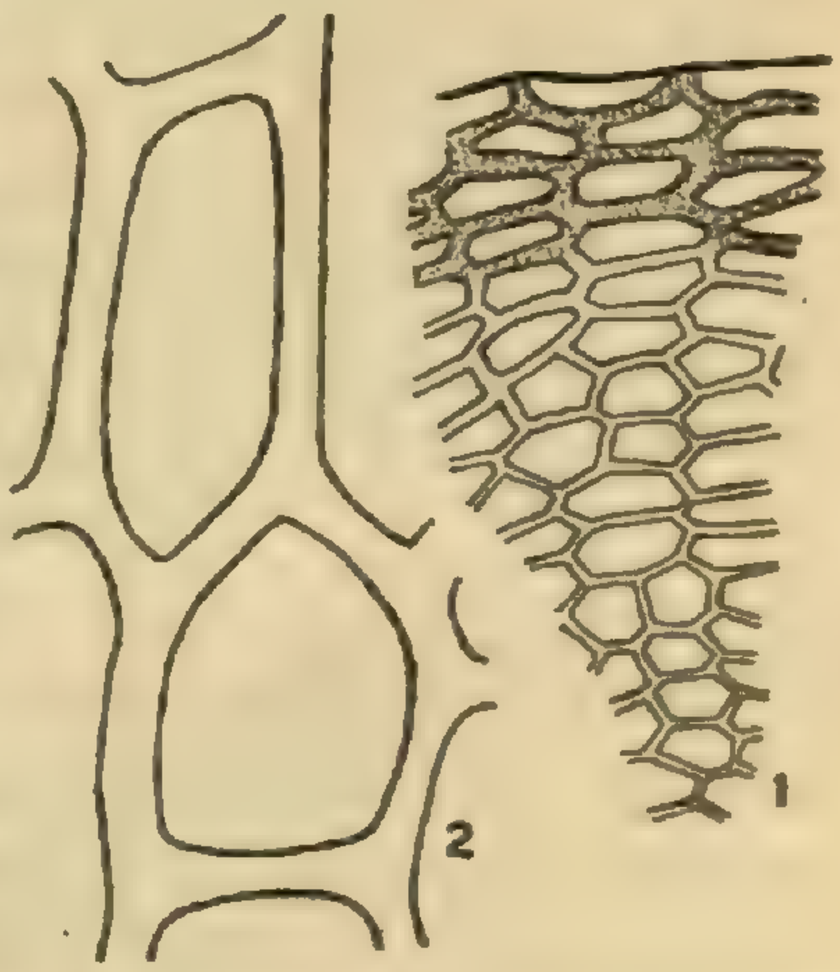
New ferns from tropical America—III

MARGARET SLOSSON

(WITH PLATE 26)

Trichomanes rhipidophyllum Slosson, sp. nov.

Rhizome creeping, about 5 mm. in diameter, thickly tomentose; stipes brown and tomentose to within about 1 mm. of the lamina, then green, slightly hairy, and winged by the narrowly and abruptly decurrent base of the lamina, in fertile fronds 5–7 mm. long, in sterile 1.5–3 mm. long; laminae shining bright green, delicately papyraceous, the fertile 0.8–1.1 cm. long, 0.7–1.3 cm. broad, suborbicular, almost semicircular, or subtrapezoid, at apex slightly once cleft, at base subtruncate or cuneate, the sterile 0.4–1.3 cm. long, 0.5–1.5 cm. broad, round-reniform to ovate or broadly obovate; margins irregularly undulate or sublobate, marginal hairs few, slender, simple or binate; surfaces or at least the lower one with a few short club-shaped mostly 2-celled hairs on the veins; veins few, distant, in the sterile fronds subflabellately forked, midveins of fertile fronds flexuose, with about 3 pairs of branches forked 1–4 times, spurious veins short, almost none; cells of the lamina between the veins variable, mostly narrow, 0.056–0.116 mm. long, 0.020–0.040 mm. broad, their walls 0.004–0.008 mm. broad; involucres 1–2, borne at the base of the central cleft of the lamina, almost wholly exserted, the lips 1.5 mm. broad, their brown border 1–4 cells deep; spores globose, 0.044–0.056 mm. in diameter.



Trichomanes rhipidophyllum.
1, cellular structure of the margin of the lip of the involucre, enlarged; 2, cells from between the veins of a sterile frond, very much enlarged.

Type in the Underwood Herbarium at the New York Botanical Garden, collected on a tree in a damp forest near Onaca, Colombia, at an altitude of 760 m., Aug. 24, 1898–99, *Herbert H. Smith 2445*. A note on the label says "not observed elsewhere." A very distinct species belonging to the section or subgenus *Didymoglossum*,

not likely to be mistaken for any other. Marked by its bright shining green color, rounded, undulate or not more than sublobate margins, and few flabellately forked veins tapering toward the apex. From *Trichomanes sphenoides* Kunze, which also has flabellately forked veins tapering toward the apex, it may be easily distinguished by the greater distance between the tips of the true veins, varying from .5 to 2 or 2.5 mm., and by the very thick walls of the cells of the laminae.

Polystichum machaerophyllum Slosson sp. nov.

Rhizome erect, its scales light brown, 2.5–6 mm. long, ovate to oblong, fimbriate or subfimbriate; scales of lower part of the stipes similar, passing into minute scales scattered over both surfaces of the frond, which are elongate-caudate, entire or slightly toothed, from a short more or less fimbriate-ciliate base; fronds up to 51 cm. long, up to 7.1 cm. broad; stipes 2.5–20.5 cm. long, brownish-stramineous or greenish, channeled on the face, rounded at the back, the upper part channeled also or flattened on the sides; rachis similar to upper part of the stipe; laminae brownish olive, lanceolate or lance-linear, slightly tapering toward base, pinnate, the apex in young fronds often deltoid-acuminate, in mature fronds of two kinds, the first subcaudate, elongate-linear or lanceolate, subentire or undulate or serrate-lobate, often proliferous at tip, the second flagelliform and proliferous at tip, naked or with a few small scattered pinnae, both kinds sometimes on the same frond, the second terminating the first; pinnae mostly alternate, 8–27 to a side, usually approximate or distant, the lower short-stalked, the upper sessile or subsessile or adnate, often passing into short variously shaped often obovate segments, principal pinnae broadly cuneate-hastate, above the auricles deltoid to linear, the basal margins entire, the outer margin subentire or undulate or with one or more minute occasionally spinescent teeth or in large fronds irregularly crenately lobed, the lobes sometimes mucronate, basal auricles and apex of pinnae spinescent; texture coriaceous-chartaceous; venation pinnate, obscure, veins very oblique, about 1–4 times forked, the basal auricles with distinct midveins; sori usually about midway between the midvein and the margin of the frond, or nearer the midvein, rarely a few submarginal; indusia more or less erose or with a few cilia; sporangia glabrous; spores cristate.

Type in the Underwood Herbarium at the New York Botanical Garden, collected at Arroyo del Medio, above the falls, Sierra

Nipe, Oriente, Cuba, altitude 450–550 meters, December 22, 1909, *J. A. Shafer 3262*. The label reads: "Shaded rocks near water."

This plant is closely related to both *Polystichum ilicifolium* Fée and *P. triangulum* (L.) Fée, and very likely may be a hybrid between the two. Numerous specimens have been seen, all Cuban, and excepting Wright's specimens, all from the Province of Oriente. Wright's specimens bear the indefinite inscription of "Cuba" and "Cuba orientale," but are dated 1859, 1860, and 1865. During the first two years Wright is known to have collected in the Province of Oriente, but in 1865 he is believed to have collected only in the western part of Cuba.*

Polystichum machaerophyllum in a mature state is easily distinguished from *P. triangulum* by the peculiar apices of the fronds, varying from long-drawn-out to flagelliform, non-proliferous to proliferous. It is more likely to be confused with *P. ilicifolium*, but may be known by the proportionately broader and shorter laminae; their darker olive-green color, resembling that of *P. triangulum;* and the larger and longer pinnae, distinctly biauriculate at base, with the part above the basal auricles not short and margined with large sharp oblique spinescent teeth, as in *P. ilicifolium*, but more or less extended and subentire or very slightly toothed or crenately lobed, the lobes entire or minutely mucronate. The indusia are peculiar, varying from only slightly erose to markedly so with a few cilia. The indusia in *P. triangulum* are entire, and in *P. ilicifolium* vary from markedly erose to conspicuously long-ciliate. *P. decoratum* Maxon, the only other Cuban *Polystichum* known with fronds flagelliform at apex, may be readily recognized by its pinnae widely excised, not auricled, at base on the lower side.

The following specimens of *P. machaerophyllum* at the New York Botanical Garden and in the U. S. National Herbarium in Washington have been examined:

CUBA: Camp La Gloria, south of Sierra Moa, Oriente, Dec. 24–30, 1910, *Shafer 8096;* bank of river among stones, Camp La Barga, Oriente, altitude 450 meters, February 22–26, 1910, *Shafer 4127;* on moist rocks, Cooper's Ranch, base of El Yunque Mountain, Baracoa, March, 1903, *Underwood & Earle 1179, 1180;*

* See L. M. Underwood, A Summary of Charles Wright's Explorations in Cuba. Bull. Torrey Club 32: 298, 300. 1905.

vicinity of Baracoa, February 1–7, 1902, *Pollard, Palmer & Palmer 237;* "in Cuba Orientale," 1859, 1860, *C. Wright 828* in part; without specific locality, 1865, *C. Wright 828* in part.*

Explanation of plate 26

1–3. *Trichomanes rhipidophyllum;* 1, rootstocks and leaves, slightly reduced; 2, 3, sterile and fertile frond, enlarged, showing venation; *H. H. Smith 2445.*

4, 5, and unnumbered figures. *Polystichum machaerophyllum;* 4, indusia, enlarged, *Shafer 3262;* 5, scale from stipe, enlarged, *Wright 828;* unnumbered figures, various forms of the plant, reduced, *Shafer 3262.* (Some of the basal auricles of the pinnae do not show clearly in the photograph, owing to a slight infolding of the dried specimens.)

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* In the Underwood Herbarium and in the U. S. National Herbarium the remainder of Wright's no. 828 is *P. decoratum.*

INDEX TO AMERICAN BOTANICAL LITERATURE

1907–1913

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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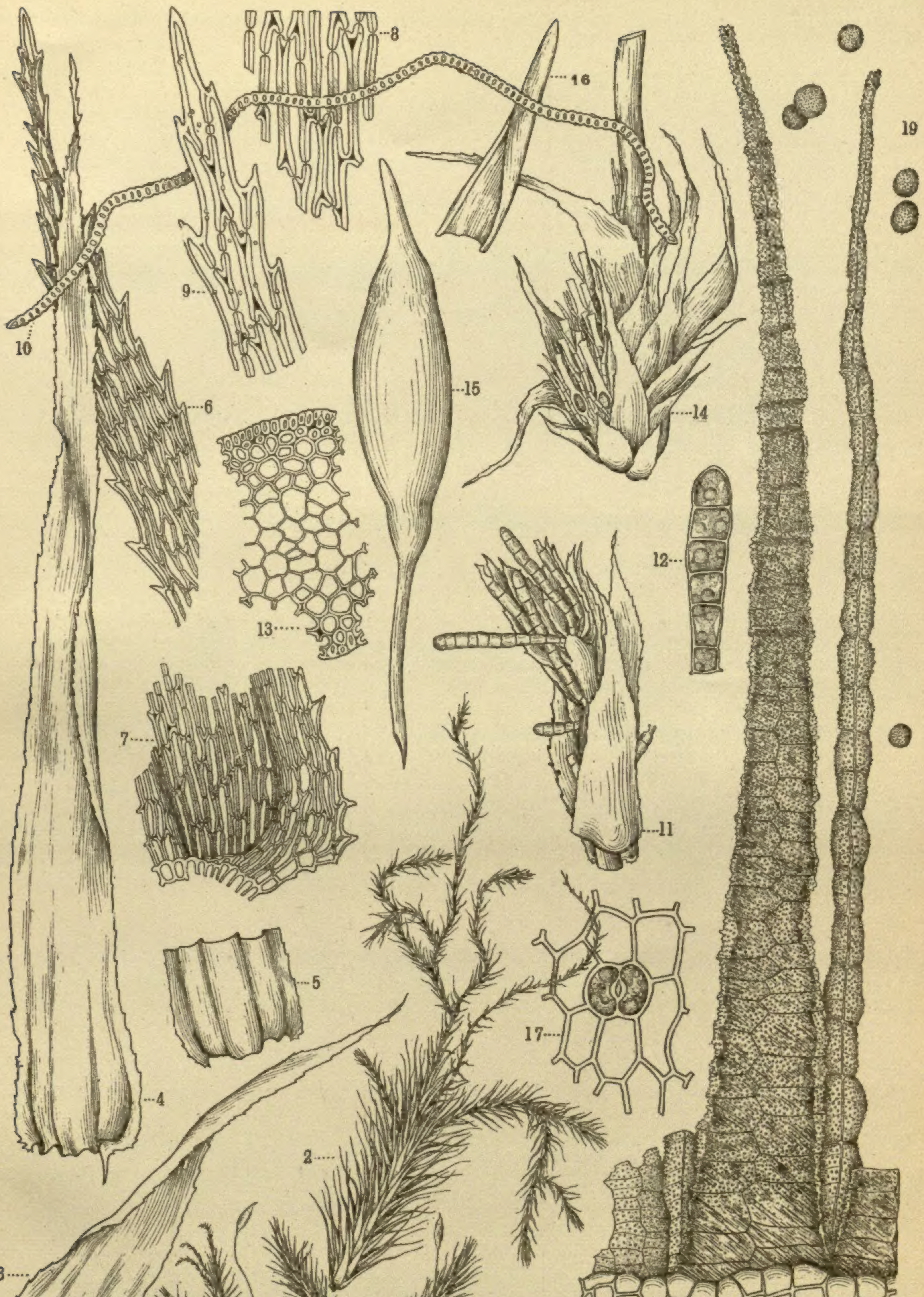

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